FISHERY RESEARCH

SNAKE RIVER SOCKEYE SALMON CAPTIVE BROODSTOCK PROGRAM RESEARCH ELEMENT

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Prepared by:

Mike Peterson, Senior Fisheries Research Biologist
Kurtis Plaster, Senior Fisheries Technician
Kip Kruse, Senior Fisheries Technician
Katie McBaine, Fisheries Technician
and
Christine Kozfkay, Principal Fishery Research Biologist

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SNAKE RIVER SOCKEYE SALMON CAPTIVE BROODSTOCK PROGRAM RESEARCH ELEMENT

2011 Annual Project Progress Report

Part 1—Project Overview
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By

Mike Peterson
Kurtis Plaster
Kip Kruse
Katie McBaine
Christine Kozfkay

Idaho Department of Fish and Game
600 South Walnut Street
P.O. Box 25
Boise, Idaho 83707

To:

U.S. Department of Energy
Bonneville Power Administration
Division of Fish and Wildlife
P.O. Box 3621
Portland, OR 97283-3621

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PART 1—PROJECT OVERVIEW

BACKGROUND

The Idaho Department of Fish and Game (IDFG) initiated the Snake River Sockeye Salmon *Oncorhynchus nerka* Captive Broodstock Program in May 1991 in response to the decline of anadromous returns to the Sawtooth Valley in central Idaho. Waples et al. (1991) described Snake River sockeye salmon as a species on the threshold of extinction, and it was listed as endangered under the Endangered Species Act (ESA) on November 20, 1991 (ESA; 16 U.S.C.A. §§1531 to 1544). Snake River sockeye salmon are one of 28 stocks of Pacific salmon and steelhead *(Genus: Oncorhynchus)* in the Columbia River basin currently listed as threatened or endangered under the Endangered Species Act (http://www.nwr.noaa.gov/ESA-Salmon-Listings/upload/snapshot-7-09.pdf) (NOAA 2005).

Historically, Redfish, Alturas, Pettit, Stanley, and Yellowbelly lakes supported sockeye salmon in the Sawtooth Valley (Chapman et al. 1990; Evermann 1895; Bjornn et al. 1968) (Figure 1). Historical observations and discussions with local residents by Evermann (1895; 1896) described the Sawtooth Valley lakes as being important spawning and rearing areas for sockeye salmon; actual adult escapement enumeration or estimations were not conducted. Adult sockeye salmon escapement to Redfish Lake was enumerated from 1954 through 1966 by the IDFG, University of Idaho, and the United States Bureau of Commercial Fisheries. During this time, adult escapement ranged from a high of 4,361 in 1955 to a low of 11 in 1961 (Bjornn et al. 1968). Adult escapement enumeration was reinitiated in 1985 by the IDFG. Between 1985 and 1990, 62 adults were estimated to have returned to the Sawtooth Valley. No redds or anadromous adults were identified in Redfish Lake in 1990. Hydropower development, water withdrawal and diversions, water storage, harvest, predation, and inadequate regulatory mechanisms were outlined as factors contributing to the Snake River sockeye salmon's decline (Federal Register 1991).

The National Marine Fisheries Service (NMFS) listed Snake River sockeye salmon as an endangered species under the 1973 Endangered Species Act (as amended in 1978) in November of 1991 (Federal Register 1991). A population is considered a distinct population segment and, hence, a species for purposes of the Endangered Species Act if it represents an evolutionary significant unit of the biological species (Waples 1991). To be considered an evolutionary significant unit, a stock must satisfy two criteria: 1) it must be reproductively isolated from other conspecific population units; and 2) it must represent an important component in the evolutionary legacy of the biological species (Waples 1991). At the time of listing, the Redfish Lake sockeye salmon population was the only remaining sockeye salmon population of the Snake River sockeye salmon stock. Snake River sockeye salmon are one of three remaining stocks of sockeye salmon in the Columbia River system; the other two stocks, Okanogan Lake sockeye salmon and Wenatchee Lake sockeye salmon, are located in tributaries of the upper Columbia River. Approximately 1,127 river kilometers separate Snake River sockeye salmon from the nearest sockeye salmon populations in the upper Columbia River. Additionally, there has been no reported evidence of straying of sockeye salmon from the upper Columbia River into Redfish Lake (Waples et al. 1991; Winans et al. 1996). Mitochondrial DNA analyses completed in 2003 confirmed the genetic isolation of the upper Columbia River stocks from the Snake River sockeye salmon stock (Faler and Powell 2003).

Sockeye salmon returning to Redfish Lake travel a greater distance from the Pacific Ocean (1,448 river kilometers) and to a higher elevation (2,138 meters) than any other sockeye salmon population in the world. Additionally, Redfish Lake supports the species' southernmost

population within its recognized range (Burgner 1991). Together these characteristics presented a strong argument for the ecological uniqueness of the Snake River habitat and for the unique adaptive genetic characteristics of the Snake River sockeye salmon stock (Waples et al. 1991).

Genetic investigations conducted during and after Snake River sockeye salmon were listed further refined genetic relationships between anadromous sockeye salmon, residual sockeye salmon, and resident kokanee present in Redfish Lake. The presence of all three of these life history strategies of *O. nerka* in Redfish Lake complicated the ESA listing. Anadromous *O. nerka* (sockeye salmon) spawn on the shoals of the lake in October and November. Juveniles out-migrate during the spring from their nursery lake at age-1 or age-2 and remain in the ocean for one to three years before returning to their natal area to spawn. Residual *O. nerka* (sockeye salmon) spawn with anadromous sockeye salmon on the shoals of the lake in October and November. Residual sockeye salmon spend their entire life in their nursery lake. Variable proportions of anadromous and residual progeny may conform to a residual life history pattern. Resident *O. nerka* (kokanee) also complete their life cycle in freshwater. They remain in Redfish Lake until maturation and spawn in Fishhook Creek, a tributary creek to Redfish Lake, in August and September. Kokanee are indigenous to Redfish Lake but were periodically stocked from a range of non-indigenous hatchery sources beginning in 1930 and continuing through 1972 (Bowler 1990). Redfish Lake anadromous sockeye salmon, residual sockeye salmon, and out-migrants were determined to be genetically similar, whereas kokanee were found to be genetically different (Brannon et al. 1992, 1994; Cummings et al. 1997; Waples et al. 1997). Because of their genetic similarity, residual sockeye salmon were added to the ESU listing in 1992.

SNAKE RIVER SOCKEYE SALMON CAPTIVE BROODSTOCK PROGRAM

The Snake River Sockeye Salmon Captive Broodstock Program collected fish from the following sources for broodstock and reintroduction purposes: 1) anadromous adult returns that were trapped between 1990 and 1998 and retained for hatchery spawning, 2) residual adults that were trapped between 1992 and 1995 and retained for hatchery spawning, and 3) smolts that were trapped between 1991 and 1993, reared until maturity, and spawned in the hatchery. Seventh generation lineages of the founders are currently in captive broodstock culture. Both IDFG and National Oceanic and Atmospheric Administration (NOAA) Fisheries maintain Snake River sockeye salmon captive broodstocks. Groups of fish are reared at two facilities to avoid the potential catastrophic loss of the unique genetics of the stock. Idaho Department of Fish and Game rears annual captive broodstocks from the egg stage to maturity at Eagle Fish Hatchery (EFH) in Eagle, Idaho (Johnson 1993; Johnson and Pravecek 1995, 1996; Pravecek and Johnson 1997; Pravecek and Kline 1998; Kline and Heindel 1999; Kline et al. 2003a, 2003b; Kline and Willard 2001; Willard et al. 2003a; Baker et al. 2005a, 2005b, 2006, 2007, 2008). Additionally, NOAA Fisheries rears duplicate captive broodstock from the egg stage to maturity at the Manchester Research Station (MRS) and Burley Creek Hatchery (BCH) near Seattle, Washington (Flagg 1993; Flagg and McAuley 1994; Flagg et al. 1996, 2001; Frost et al. 2002, 2008).

The IDFG and NOAA Fisheries captive broodstock programs have produced approximately 5,408,369 eyed eggs from 1991 through 2011 (Table 1). Each year approximately 1,200 eggs are selected to be reared in the hatchery as an annual captive broodstock; the remaining eggs are utilized for reintroduction into the habitat.

The development of captive broodstock program reintroduction plans follows a "spread-the-risk" philosophy incorporating multiple release strategies and multiple lakes (Hebdon et al. 2004). Progeny from the captive broodstock program are reintroduced to Sawtooth Valley waters at different life stages using a variety of release options including: 1) eyed egg plants to in-lake incubator boxes in November and December, 2) presmolt releases direct to lakes in October, 3) smolt releases to outlet streams in May, and 4) prespawn adult releases (hatchery-reared) direct to lakes in September. All hatchery-reared presmolt and smolt release groups are uniquely marked to identify release strategy and release origin. To date, approximately 3,828,237 sockeye salmon eggs and fish have been reintroduced to Sawtooth Valley waters (Table 2). Overall survival to release (over different strategies) from the eyed egg stage of development has averaged just over 70% for the program.

Life history traits exhibited by natural sockeye salmon and habitat carrying capacity evaluations conducted by the Shoshone-Bannock Tribes (SBT) (Teuscher and Taki 1995, 1996; Taki and Mikkelsen 1997; Taki et al. 1999; Griswold et al. 2000; Lewis et al. 2000; Kohler et al. 2001, 2002, 2008) influence annual release plans. Bjornn et al. (1968) conducted smolt out-migration and adult return monitoring between 1954 and 1966; their work provides a detailed account of sockeye salmon life history in Redfish Lake. Smolt out-migration from Redfish Lake begins in early April, peaks in mid-May, and is complete by mid-June. Smolts out-migrate at either age-1 or age-2; the proportion of age-1 and age-2 smolts varies every year. During their 11-year study, Bjornn et al. (1968) noted a dominance of age-1 smolts for six of the 11 years. Age-2 smolts ranged from 2% to 77% of the total out-migration over the course of the early monitoring effort. Age-2 smolts are common in many other sockeye salmon lakes. The reasons for the additional freshwater residence time are unclear (Burgner 1991). Smolt fork length ranges between 45 mm and 140 mm. Adult sockeye salmon begin arriving at Redfish Lake Creek in mid-July and continue escapement through mid-October. Sockeye salmon spawn over submerged beach substrate of the lake; spawning peaks in mid-October. Returning adults are primarily two-ocean fish (Bjornn et al. 1968).

Efforts to prevent extinction of the Snake River sockeye salmon are coordinated through the Stanley Basin Sockeye Technical Oversight Committee (SBSTOC), a team of biologists representing IDFG, the SBT, NOAA Fisheries, and the University of Idaho. The Bonneville Power Administration provides coordination for the SBSTOC process.

PROJECT GOALS

The immediate goal of the program is to utilize captive broodstock technology to conserve the population's unique genetics. Long-term goals include increasing the number of individuals in the population to address NOAA's interim abundance guidelines and to provide sport and treaty harvest opportunity. Draft ESA delisting criteria for Snake River sockeye salmon includes the return of 1,000 adults to Redfish Lake, 500 adults to Pettit Lake, and 500 adults to Alturas Lake for two generations (NMFS 2002). Interim abundance targets must be met without relying on hatchery production (e.g., natural origin adults).

PROJECT OBJECTIVES

1. Develop captive broodstocks from Redfish Lake sockeye salmon, culture broodstocks, and produce progeny for reintroduction.

2. Determine the contribution hatchery-produced sockeye salmon make toward avoiding population extinction and increasing population abundance.

3. Describe *O. nerka* population characteristics for Sawtooth Valley lakes in relation to carrying capacity and broodstock program reintroduction efforts.

4. Utilize genetic analysis to discern the origin of natural and hatchery sockeye salmon to provide maximum effectiveness in their utilization within the broodstock program.

5. Transfer technology through participation in the technical oversight committee process, provide written activity reports, and participate in essential program management and planning activities.

Idaho Department of Fish and Game's participation in the Snake River Sockeye Salmon Captive Broodstock Program includes two areas of effort: 1) sockeye salmon captive broodstock culture, and 2) sockeye salmon research and evaluations. Although objectives and tasks from both components overlap and contribute to achieving the same goals, work directly related to sockeye salmon captive broodstock culture appears under a separate cover (Baker et al. 2011). Research and evaluation activities associated with Snake River sockeye salmon are permitted under NOAA permit Nos. 1120, 1124, and 1481 (for a review see Kline 1994; Kline and Younk 1995; Kline and Lamansky 1997; Hebdon et al. 2000; Hebdon et al. 2002; Hebdon et al. 2003; Willard et al. 2003b; Willard et al. 2005). This report details fisheries research information collected between January 1 and December 31, 2011. Research information includes *O. nerka* population monitoring in Sawtooth Valley lakes, sport fishery evaluation on Redfish Lake, smolt out-migration monitoring and evaluation at lake outlets, telemetry studies of mature adult sockeye salmon released to Sawtooth Valley lakes for natural spawning, and predator investigations in tributaries to Redfish and Alturas lakes.

STUDY AREA

The program's recovery efforts focus on Redfish, Pettit, and Alturas lakes in the Sawtooth Valley located within the Sawtooth National Recreation Area (Figure 1). These lakes provide critical spawning and rearing habitat under the ESA listing. Lakes in the Sawtooth Valley are glacial-carved and considered oligotrophic. The three lakes range in elevation from 1,996 m (Redfish Lake) to 2,138 m (Alturas Lake) and are located 1,448 km (Redfish Lake) to 1,469 km (Alturas Lake) from the Pacific Ocean. Redfish Lake is the largest of the three lakes (615 ha), Pettit Lake is the smallest (160 ha), and Alturas Lake (338 ha) is intermediate in surface area (Table 3). Reintroduction efforts have been ongoing in Redfish Lake since 1993, Pettit Lake since 1995, and Alturas Lake since 1997.

In addition to *O. nerka*, numerous native and nonnative fish reside in the study lakes and streams within the Sawtooth Valley. Native fish present in Sawtooth Valley waters include: Chinook salmon *O. tshawytscha*, rainbow trout/steelhead *O. mykiss*, westslope cutthroat trout *O. clarkii lewisi*, bull trout *Salvelinus confluentus*, sucker *Catostomus* spp., northern pikeminnow *Ptychocheilus oregonensis*, mountain whitefish *Prosopium williamsoni*, redside shiner *Richardsonius balteatus*, dace *Rhinichthys* spp., and sculpin *Cottus* spp. Nonnative species present in Sawtooth Valley waters include lake trout *S. namaycush* (Stanley Lake only) and brook trout *S. fontinalis*. Rainbow trout are released into Pettit, Alturas, and Stanley lakes in the summer to increase sportfishing opportunities. Sportfishing on Pettit, Alturas, and Stanley lakes is covered by Idaho's statewide general fishing regulations, which allow harvest of six trout per

day (excluding bull trout, which must be released if caught) and 15 kokanee per day with no seasonal closures. Sportfishing regulations on Redfish Lake restrict kokanee fishing/harvest to January 1 through August 7 to protect residual sockeye salmon. No trout have been stocked in Redfish Lake since 1992.

2010 and 2011 Captive Broodstock Program Egg and Juvenile Supplementation

All hatchery origin sockeye salmon released to Sawtooth Valley waters were either adipose fin-clipped or coded-wire-tagged to distinguish hatchery rearing origin and/or release strategy. A subsample of some of the release groups was PIT tagged prior to release.

In 2010, 246,711 sockeye salmon and 59,683 sockeye salmon eyed eggs were released into Sawtooth Valley waters from the captive broodstock program (Table 5). Smolts were released to the Salmon River on May 4, 2010. A total of 179,278 BY08 smolts were released at two separate release sites (118,780 below the river water intake to Sawtooth Fish Hatchery (SFH) and 60,498 into Redfish Lake Creek below the IDFG weir site). Smolts were reared at two locations: IDFG SFH and ODFW Oxbow Fish Hatchery (OFH). All sockeye smolts released were coded-wire-tagged and had representative groups PIT tagged (11,945 OFH, 51,661 SFH). All presmolts released in 2010 were age-0 fish from brood year 2009 (BY09) reared at SFH and EFH (49,488 reared at SFH, 16,363 reared at EFH). Redfish Lake received 31,413 presmolts, Alturas Lake received 16,363 presmolts (1,319 PIT tagged), and Pettit Lake received 18,075 presmolts in July and October by direct lake releases. A total of 372 hatchery-produced adult sockeye salmon were released to Redfish Lake for volitional spawning in September. In addition, 1,210 anadromous return adult sockeye salmon were released into Redfish Lake between September 8 and October 7, 2010 for volitional spawning. In November and December, 59,683 eyed eggs reared at BCH and EFH were planted in Alturas Lake in 2010.

In 2011, 242,650 sockeye salmon and 42,665 sockeye salmon eyed eggs were released into Sawtooth Valley waters from the captive broodstock program (Table 5). Smolts were released to Redfish Lake Creek on May 12, 2011. Smolts were reared at two locations: IDFG SFH and ODFW OFH. A total of 191,048 BY09 smolts were released at Redfish Lake Creek (54,761 from OFH, 135,614 from SFH, and 673 from MRS below the IDFG weir site). All sockeye smolts released were coded-wire-tagged and had representative groups PIT tagged (9,973 OFH, 51,672 SFH, and 673 MRS). All presmolts released in 2011 were age-0 fish from brood year 2010 (BY10) reared at EFH (50,054 EFH of which 1,994 were PIT tagged), and released directly into Redfish Lake in July. A total of 558 hatchery-produced adult sockeye salmon were released to Redfish Lake for volitional spawning in September. In addition, 990 anadromous return adult sockeye salmon were released into Redfish Lake between August 23 and October 14, 2011 for volitional spawning. In November and December, 42,665 eyed eggs reared at BCH and EFH were planted in Alturas Lake.

Table 1. Eyed egg production by IDFG and NOAA facilities for the Snake River sockeye salmon captive broodstock program 1991-2011.

Brood Year	Eyed Eggs Produced By IDFG	Eyed Eggs Produced By NOAA
1991	1,978	0
1992	36	0
1993	13,647	0
1994	259,536	48,000
1995	3,006	0
1996	110,756	381,500
1997	152,760	171,965
1998	15,580	47,533
1999	63,168	65,400
2000	253,047	94,500
2001	121,320	90,859
2002	66,324	60,516
2003	303,983	139,359
2004	140,823	135,699
2005	145,207	143,362
2006	258,342	190,603
2007	175,810	192,354
2008	220,334	134,105
2009	290,968	129,849
2010	228,822	165,078
2011	249,522	142,718
Total:	**3,074,969**	**2,333,400**

Table 2. Snake River sockeye salmon captive broodstock program egg and fish reintroduction history 1993-2011.

Year of Reintroduction	Eyed Eggs	Presmolts	Smolts	Hatchery-Reared Adults	Anadromous Adults
1993	0	0	0	20	0
1994	0	14,119	0	65	0
1995	0	91,572	3,794	0	0
1996	105,000	1,932	11,545	120	0
1997	105,767	255,711	0	120	0
1998	0	141,871	81,615	0	0
1999	20,311	40,271	9,718	18	3
2000	65,200	72,114	148	71	200
2001	0	106,166	13,915	65	14
2002	30,924	140,410	38,672	178	12
2003	199,666	76,788	0	315	0
2004	49,134	130,716	96	241	0
2005	51,239	72,108	78,330	173	0
2006	184,596	107,292	86,052	464	0
2007	51,008	82,105	101,676	494	0
2008	67,984	84,005	150,395	398	571
2009	75,079	59,538	173,055	682	667
2010	59,683	65,851	179,278	372	1,210
2011	42,665	50,054	191,048	558	990
Total	**1,108,256**	**1,592,623**	**1,118,973**	**4,354**	**3,667**

Table 3. Physical and morphometric characteristics of three study lakes located in the Sawtooth Valley, Idaho.

Surface Area (ha)	Elevation (m)	Volume ($m^3 \times 10^6$)	Mean Depth (m)	Maximum Depth (m)	Drainage Area (km^2)
		Redfish Lake			
615	1,996	269.9	44	91	108.1
		Alturas Lake			
338	2,138	108.2	32	53	75.7
		Pettit Lake			
160	2,132	45.0	28	52	27.4

Table 4. Sockeye salmon releases to Sawtooth Valley waters in 2010.

Release Location	Strategy (Brood Year)	Release Date	Number Released	Marks[a]	Number PIT tagged	Mean Release Weight (g)	Rearing Location[b]
Redfish Lake Creek (below weir)	Smolt (2008)	05/04/2010	60,498	CWT	31,813	42.4	SFH/OFH
Salmon River (above SFH weir)	Smolt (2008)	05/04/2010	118,780	CWT	31,793	16.2	SFH/OFH
Alturas Lake (direct lake)	Presmolt (2009)	07/27/2010	16,363	AD	1,319	11.4	EFH
Pettit Lake (direct lake)	Presmolt (2009)	10/07/2010	18,075	AD	0	2.9	SFH
Redfish Lake (direct lake)	Presmolt (2009)	10/07/2010	31,413	AD	0	2.9	SFH
Redfish Lake (direct lake)	Adult Captives	09/08/2010	11	AD	11	2,702.4	BCH
		09/15/2010	2	AD	2	926.5	EFH
		09/15/2010	187	AD	187	1,008.9	BCH
		09/17/2010	172	AD	172	1,227.0	EFH
	Adult Anadromous	09/10/2010	331	Mix	2	1,565.3	EFH
		09/14/2010	297	Mix	5	1,542.1	EFH
		08/12-09/09/2010	582	Mix	16	NA	Direct
Alturas Lake (direct lake)	Eyed egg (2010)	12/01/2010	2,455	NA	NA	NA	BCH
		12/01/2010	15,296	NA	NA	NA	EFH
		12/08/2010	31,708	NA	NA	NA	EFH
		12/16/2010	461	NA	NA	NA	BCH
		12/16/2010	9,763	NA	NA	NA	EFH

[a] AD = adipose fin-clip, CWT = coded-wire-tagged.
[b] SFH = Idaho Department of Fish and Game Sawtooth Fish Hatchery; OFH = Oregon Department of Fish and Wildlife Oxbow Fish Hatchery; EFH = Idaho Department of Fish and Game Eagle Fish Hatchery; BCH = National Oceanic and Atmospheric Administration Burley Creek Hatchery.

Table 5. Sockeye salmon releases to Sawtooth Valley waters in 2011.

Release Location	Strategy (Brood Year)	Release Date	Number Released	Marks[a]	Number PIT-tagged	Mean Release Weight (g)	Rearing Location[b]
Redfish Lake Creek (below weir)	Smolt (2009)	05/12/2011	54,761	CWT	10,382	46.8	OFH
Redfish Lake Creek (below weir)	Smolt (2009)	05/12/2011	135,614	AD/CWT	52,036	8.3	SFH
Redfish Lake Creek (below weir)	Smolt (2009)	05/12/2011	673	AD	673	84.0	MRS
Redfish Lake (direct lake)	Presmolt (2010)	07/12/2011	50,054	AD	1,994	7.4	EFH
Redfish Lake (direct lake)	Adult Captive	09/13/2011	34	AD	34	1,451	BCH
		09/13/2011	196	AD	194	509	BCH
		09/16/2011	1	AD	1	2,768	EFH
		09/16/2011	327	AD	327	1,687	EFH
	Adult Anadromous	09/14/2011	350	Mix	85	1,532	EFH
		8/23-10/14/2011	640	Mix	138	1,532	Direct
Alturas Lake	Eyed egg (2011)	11/22/2011	8,056	NA	NA	NA	EFH
		12/01/2011	24,174	NA	NA	NA	EFH
		12/15/2011	9,389	NA	NA	NA	EFH
		12/15/2011	1,046	NA	NA	NA	BCH

[a] AD = adipose fin-clip, CWT = coded-wire-tagged.

[b] SFH = Idaho Department of Fish and Game Sawtooth Fish Hatchery; OFH = Oregon Department of Fish and Wildlife Oxbow Fish Hatchery; EFH = Idaho Department of Fish and Game Eagle Fish Hatchery; BCH = National Oceanic and Atmospheric Administration Burley Creek Hatchery; MRS = National Oceanic Administration Manchester Research Station.

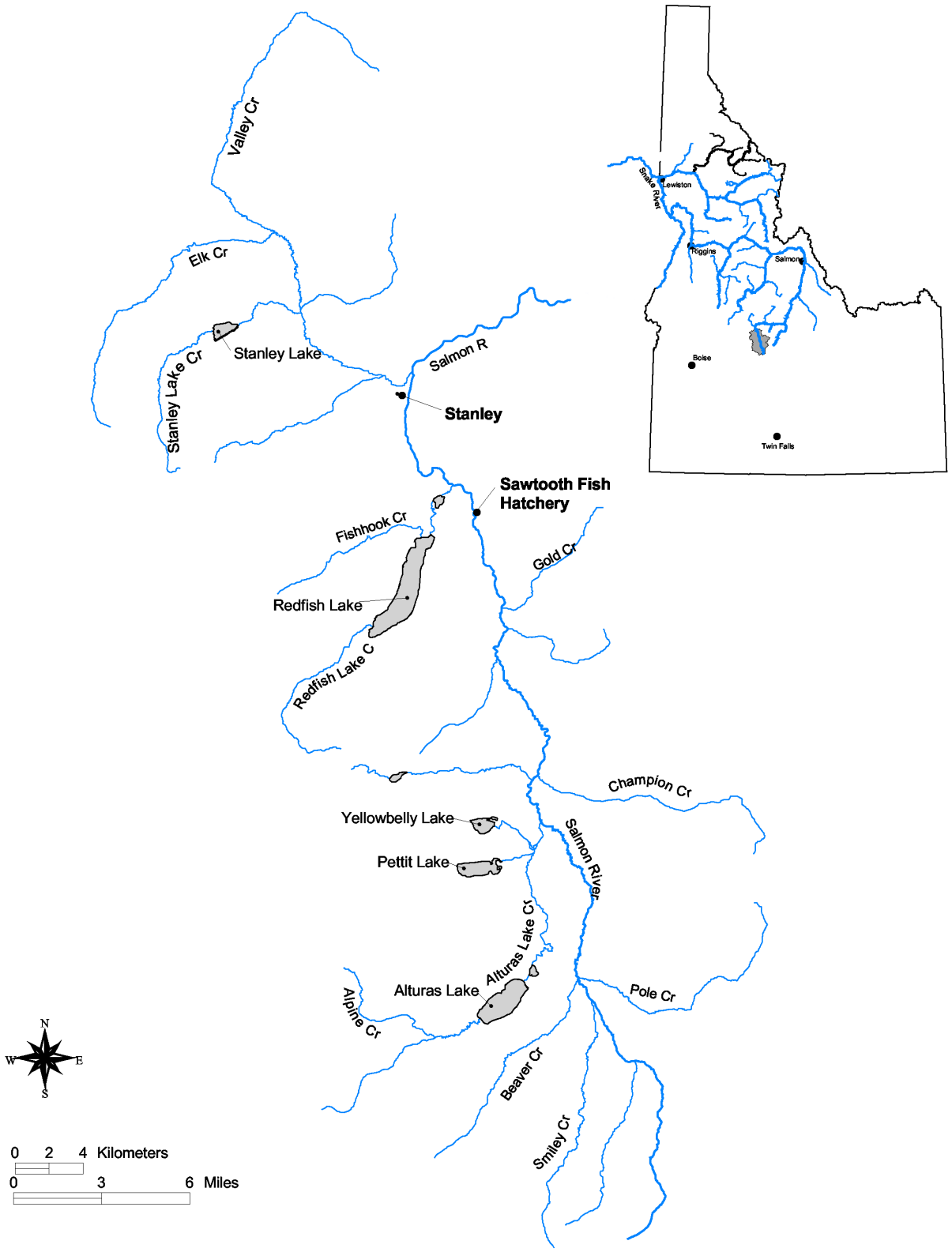

Figure 1. Map of the upper Salmon River watershed located in the Sawtooth Valley, Idaho.

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PART 2—ONCORHYNCHUS NERKA POPULATION MONITORING AND REDFISH LAKE SPORT FISHERY INVESTIGATIONS

INTRODUCTION

Understanding the dynamics of *O. nerka* populations in the Sawtooth Valley lakes is a vital part of sockeye salmon restoration efforts. Knowledge of *O. nerka* abundance coupled with limnology data (collected and reported by the Shoshone-Bannock Tribes [SBT]) is necessary for making responsible decisions regarding the reintroduction of sockeye salmon juveniles from the captive broodstock program. Utilizing multiple release strategies at various life stages allows program managers to design reintroduction plans that take advantage of the nursery lakes' current carrying capacities, which are estimated by trawling, hydroacoustic surveys, and limnological surveys (hydroacoustic and limnological surveys conducted and reported by the SBT). Productivity in the lakes varies annually and the presence of kokanee in the nursery lakes creates increased competition for limited food sources between kokanee and sockeye salmon. During years in which a lake is experiencing low productivity and/or high kokanee abundance, the program limits reintroduction efforts of individuals that would spend more time in nursery lakes and diverts individuals to more productive lakes.

The kokanee fishery on Redfish Lake was closed in 1993 due to the presence of ESA listed residual sockeye salmon but was reopened in 1995 (NOAA Permit 1481). The kokanee fishery was reopened based on the recommendation of the SBSTOC to reduce kokanee competition with sockeye salmon by removing spawning age kokanee through angler harvest. Permit 1481 (NOAA) requires IDFG to monitor angler harvest of listed sockeye salmon in Redfish Lake during the kokanee fishing season. The kokanee season on Redfish Lake opens on January 1 and closes on August 7, when mature kokanee initiate spawning in Fishhook Creek, while residual sockeye salmon remain in the lake.

The roving creel survey conducted on Redfish Lake during 2011 was designed to estimate total kokanee harvest and to collect tissue samples for genetic analysis from angler-harvested kokanee. The genetic analysis is used to estimate the number of unmarked sockeye salmon harvested incidental to the kokanee fishery within the lake.

METHODS

Oncorhynchus nerka Population Monitoring

To estimate *O. nerka* (kokanee and sockeye salmon) abundance, density, and biomass in Sawtooth Valley lakes, midwater trawling was conducted at night during the dark (new) phase of the moon in August. Spawning-age kokanee (>250 mm fork length) in Redfish and Alturas lakes migrate to tributaries to spawn in August; therefore, trawling was conducted in late August to prevent the collection of biased trawl catch data, and because juvenile *O. nerka* that remain in valley lakes are tightly stratified during this time of the year. Redfish, Pettit, and Alturas lakes were sampled August 29–31, 2011. Trawling was performed in a stepped-oblique fashion as described by Rieman (1992) and Kline (1994). A minimum of six trawl transects were conducted per lake. Total *O. nerka* abundance, density, and biomass were estimated using a program developed by Rieman (1992). Abundance estimates generated by this program are extrapolations of actual trawl catch data to the total area of the lake mid-depth in the observed *O. nerka* stratum. Density and biomass estimates are expressed in relation to lake surface area. Whenever possible, we estimated abundance, density, and biomass by individual age class

(assuming representation in the trawl). We calculated confidence intervals using the following formula of Scheaffer et al. (1990):

$$\bar{x} \pm t\sqrt{\frac{s^2}{n}}$$

Fork length (1 mm) and weight (0.1 g) were recorded for all trawl-captured *O. nerka*; scales were removed from a subsample (a minimum of five fish from every 10 mm length group) and returned to the laboratory. Two program technicians aged scales to determine length ranges for age classification. Scales were mounted between microscope slides before aging and viewed with a microfiche (n = 19 Redfish, 20 Alturas, and 5 Pettit). Stomachs were removed and preserved for diet analysis by SBT biologists. Fin clips were stored in 100% ethanol and delivered to the IDFG Genetics Laboratory for DNA analysis (n = 31 Redfish, 81 Alturas, and 7 Pettit).

Redfish Lake Sport Fishery Investigations

A roving creel survey was conducted from May 30 through August 7, 2011 (kokanee harvest closes on August 7 to protect residual sockeye salmon) on Redfish Lake. The creel census was stratified by 14-day intervals, broken into weekday and weekend day types and morning (0800 to 1400) and evening (1401 to 2000) instantaneous count periods. Angler counts were conducted four weekdays, two weekend days, and any holiday during each 14-day interval. On each angler count day, the number of boats and bank anglers were counted from a boat for each day period (morning and evening strata). Angler count dates and times were selected randomly. Angler interviews were conducted following the completion of each instantaneous count. Anglers were asked how many fish they had harvested and/or released by species, how many hours they had fished, what their preferred target species was, whether or not they were aware of the Redfish Lake kokanee fishery, and the type of gear they used. All responses were recorded by creel personnel. Fin clips were taken from harvested kokanee that were checked by creel survey personnel. Fin clips were stored in 100% ethanol and delivered to IDFG Genetics Laboratory personnel for DNA analysis. Creel data were analyzed using the Creel Application Software computer program developed by Soupir and Brown (2002) and used to estimate angler effort, catch rates, and harvest.

RESULTS AND DISCUSSION

Oncorhynchus nerka Population Monitoring

Redfish Lake

August trawl catch on Redfish Lake (six transects, Appendix A) included 37 natural origin and zero hatchery origin (adipose fin-clipped) *O. nerka. Oncorhynchus nerka* abundance was estimated at 43,671 fish (95% CI ± 18,630). The *O. nerka* population was up 44.6% (within Redfish Lake) from the estimated abundance levels in 2010 (30,194 fish) and increased 51% from the estimated abundance of *O. nerka* for 2009 (28,923; Table 6).

Density and biomass were estimated at 71.0 fish/ha and 0.11 kg/ha, respectively (Table 6). This represented an increase of 44.6% for density and a decrease of 31.3% in biomass from estimated levels in 2010 (Peterson et al. 2012). Age-0 and age-1 *O. nerka* were represented in

the trawl sample from Redfish Lake. Age-0 fish had the highest average density (69.1 fish/ha) and the highest biomass (0.09 kg/ha; Table 7).

Alturas Lake

August trawl catch on Alturas Lake (six transects, Appendix A) included 81 natural origin *O. nerka* and zero hatchery origin (adipose fin-clipped) sockeye salmon. We estimated *O. nerka* abundance, density, and biomass at 47,739 fish (95% CI ± 31,520), 141.2 fish/ha, and 0.29 kg/ha, respectively (Table 6). Age-0, age-1, and age-3 *O. nerka* were represented in the trawl sample (Table 7). Age-0 fish had the highest density (130.54 fish/ha) and contributed 31% of the biomass (Table 7). The estimates for abundance and density were 3.6 times higher and biomass was 80% lower than 2010 estimates, respectively (Table 6).

Pettit Lake

August trawl catch on Pettit Lake (six transects, Appendix A) included seven natural origin *O. nerka* and zero hatchery origin (adipose fin-clipped) sockeye salmon. We estimated *O. nerka* abundance, density, and biomass at 3,733 fish (95% CI ± 3,307), 23.3 fish/ha, and 0.24 kg/ha, respectively (Table 6). Age-0 and age-1 *O. nerka* were represented in the trawl sample. Age-1 fish had the highest density at 13.3 fish/ha and a biomass of 0.23 kg/ha (Table 7). The estimates for abundance and density were 71.8% lower and biomass was 57.9% lower than 2010 estimates, respectively.

We experience high levels of adult escapement variation in both Fishhook Creek and Alturas Lake Creek (Table 8), which appears to cause population fluctuations within these systems. Also, Pettit Lake appears to be building a residual sockeye population and the nonnative kokanee proportion appears to be on a decreasing trend, although the results are not statistically significant (Chris Kozfkay, IDFG, personal communication). Potential behavioral differences between nonnative kokanee and sockeye may account for some of the population changes that occurred between 2010 and 2011. Pettit Lake is also very difficult to sample due to its relatively small size compared to the other two nursery lakes. During 2011, we observed most of the *O. nerka* layer within 5 meters of the surface. This may have led to the small trawl sample size (n = 7; *O. nerka* were possibly "spooking" from the boat that close to the surface). *O nerka* abundance monitoring should remain a priority for the program to monitor zooplankton abundance and help us to develop escapement goals, which are necessary to minimize kokanee and zooplankton population fluctuations. These goals should also provide a stable nursery habitat environment for sockeye salmon by reducing competition between kokanee and sockeye. Escapement goals should be discussed annually before kokanee enter the tributaries to spawn and recommendations presented to the SBSTOC for discussion and modification.

Genetic Results From Trawl Samples

In 2011, tissues for genetic analysis were collected from 125 *O. nerka* during the midwater trawling events performed by IDFG personnel. These samples were delivered to the IDFG Eagle Fish Genetics Laboratory (Eagle, Idaho) for microsatellite DNA analysis, and the results of the analysis are listed below.

Redfish Lake

In 2011, 37 fin samples were analyzed from trawl captured *O. nerka* on Redfish Lake and 15 had genotypes indicative of protected Snake River sockeye salmon (41% with 95%

confidence bounds ranging from 26% to 56%). This is comparable to the average proportions of *O. nerka* and Snake River sockeye observed between 2006-2010 of 40.3%.

Pettit Lake

In 2011, seven fin samples were analyzed from trawl captured *O. nerka* on Pettit Lake and two had genotypes indicative of protected Snake River sockeye salmon (29% with 95% confidence bounds ranging from 8% to 64%). This is 59.3% lower than the average proportions of *O. nerka* and Snake River sockeye observed between 2006-2010 of 71.3%. The small sample size captured with the midwater trawl in 2011 may have resulted in the decreased proportion of sockeye observed.

Alturas Lake

In 2011, 81 fin samples were analyzed from trawl captured *O. nerka* on Alturas Lake and none of the sample fish had genotypes indicative of protected Snake River sockeye salmon. We have not observed a Snake River sockeye in the trawl sample from Alturas Lake since initiating the genetic monitoring in 2006.

We will continue to monitor these populations utilizing microsatellite DNA analysis.

Redfish Lake Sport Fishery Investigations

In 2011, we contacted 48 angler parties (102 individual anglers) on Redfish Lake. Boat anglers made up 58.8% of those interviewed. Most anglers used lures (63.5%), followed by bait (31.7%). Total angler effort was estimated at 3,083 hours (95% CI $\pm$ 1,468; Table 9). This effort estimate represents a 9.5% increase in fishing pressure between 2011 and 2010 (Table 10). Boat anglers expended more effort (2,460 hours) than bank anglers (623 hours), which was similar to results from 2010 (Peterson et al. 2012).

The season catch rate for all fish (caught) was 0.82 fish/hour. Catch rates decreased 24% over the estimate from 2010 (Peterson et al. 2012*).* Kokanee catch rates (harvested and released) averaged 0.00 kokanee/hour for the season (Table 11). The 2011 season estimate of 0.00 kokanee/hour kept was lower than the 2010 estimate of 0.02 kokanee/hour. Bull trout catch and release rates were 0.73 bull trout/hour for weekdays and 0.17 bull trout/hour for weekends, for a season estimate of 0.48 bull trout/hour (IDFG regulations prohibit harvesting bull trout; Table 11). We also estimated that 1,490 bull trout were caught and released from Redfish Lake during 2011 (Table 12). The season catch rate for bull trout is lower than observed rates from 2009 and 2010 (0.54 and 0.73 bull trout/hour, respectively). However, we have seen a trend of overall increase in bull trout catch rates since monitoring began in 1996 (Figure 2). Cutthroat trout had catch rates of 0.24 fish/hour caught (no cutthroat harvest was documented in 2011) for the season.

The total number of fish caught (harvested and released) in Redfish Lake was estimated at 2,516 fish (95% CI $\pm$ 2,518). This was a decrease of 17.1% from the 2010 estimate (3,039 fish caught). The majority (97.4%) of all fish caught in 2011 were released. Kokanee harvest was estimated at zero fish and the number of kokanee released was estimated at zero (Table 12). We are currently investigating the idea of re-establishing a rainbow trout fishery in Redfish Lake. Creel data from 1986 and 1987 (Reingold and Davis 1987; Davis and Reingold 1988) suggests that a rainbow trout fishery within Redfish Lake could produce between 12,000-15,000

hours of effort and provide a potential increase in the number of kokanee caught and harvested as by-catch to the fishery.

The direct impact of the kokanee fishery on residual sockeye salmon (through incidental harvest) is evaluated annually using genetic analysis of tissue samples collected from kokanee in the creel (Table 13). In 2011, tissues for genetic analysis were collected from zero *O. nerka* encountered during the sport fishery by IDFG personnel (creel personnel did not observed kokanee from the sport fishery). Creel personnel will try to collect genetic samples from angler caught kokanee and capture kokanee using angling gear for genetic analysis during the 2012 creel survey. We will also initiate a volunteer angler response program aimed at collecting complete trip data for future creel analyses. This will be done by passing out postcards that can be returned to a drop box located at the boat ramp at Redfish Lake. This will be done in addition to current methodology conducted to estimate biases associated with using incomplete trip data.

Table 6. Estimated *O. nerka* population, density, and biomass for Redfish, Alturas, and Pettit lakes, 1990 to 2010.

Year	Population (± 95% CI)	Density (fish/ha)	Biomass (kg/ha)
	Redfish Lake (615 surface hectares)		
2011	43,671 (18,630)	71.0	0.11
2010	30,194 (16,139)	49.1	0.16
2009	28,923 (32,197)	47.0	0.11
2008	26,284 (13,226)	42.7	0.29
2007	73,702 (24,195)	119.8	0.84
2006	82,796 (47,407)	134.6	2.37
2005	56,220 (4,192)	91.4	0.3
2004	82,258 (3,486)	133.0	0.3
2003	81,727 (2,763)	132.9	1.6
2002	50,204 (4,085)	81.6	1.0
2001	12,980 (2,959)	21.1	<0.1
2000	10,268 (1,605)	16.7	<0.1
1999	42,916 (1,795)	69.7	0.9
1998	31,486 (1,716)	51.2	1.8
1997	55,762 (1,590)	90.7	2.5
1996	56,213 (3,526)	91.4	2.8
1995	61,646 (2,078)	100.2	4.4
1994	51,529 (4,902)	83.8	1.4
1993	49,628[a]	80.7	1.6
1992	39,481 (2,498)	64.2	1.0
1990	24,431 (11,000)	39.7	0.8
	Alturas Lake (338 surface hectares)		
2011	47,739 (31,520)	141.2	0.29
2010	10,366 (8,047)	30.7	1.42
2009	39,781 (11,697)	117.7	3.50
2008	71,088 (34,189)	210.3	2.67
2007	124,073 (23,327)	367.1	3.43
2006	105,779 (50,702)	313.0	3.51
2005	20,956 (2,136)	98.8	0.3
2004	36,206 (2,579)	107.1	1.9
2003	46,234 (5,183)	136.8	5.5
2002	24,374 (2,328)	72.1	2.2
2001	70,159 (1,696)	207.6	2.4
2000	125,462 (1,572)	371.0	2.1
1999	56,675 (4,476)	167.7	0.4
1998	65,468 (2,860)	193.7	1.4
1997	9,761 (933)	28.9	2.1
1996	13,012 (691)	38.5	1.4
1995	23,061 (1,202)	68.2	1.7
1994	5,785 (1,957)	17.1	0.4
1993	49,037 (1,443)	145.1	2.6
1992	47,237 (3,782)	139.8	2.4
1991	125,045 (1,881)	370.0	3.9
1990	126,644 (1,690)	374.7	3.3

Table 6. Continued.

Year	Population (± 95% CI)	Density (fish/ha)	Biomass (kg/ha)
	Pettit Lake (160 surface hectares)		
2011	3,733 (3,307)	23.3	0.24
2010	13,246 (5,961)	82.8	0.57
2009	4,623 (4,536)	40.2	0.08
2008	8,470 (4,640)	52.9	1.28
2007	14,746 (7,099)	92.2	3.84
2006	33,246 (12,416)	207.8	7.4
2005	23,970 (2,136)	149.8	2.2
2004	46,065 (3,288)	287.9	9.8
2003	11,961 (626)	136.8	5.5
2002	18,328 (384)	114.5	12.1
2001	16,931 (1,311)	105.8	6.1
2000	40,559 (1,317)	253.5	10.2
1999	31,422 (2,515)	196.4	6.3
1998	27,654 (862)	172.8	9.7
1997	21,730 (1,462)	135.8	5.1
1996	71,654 (911)	447.8	15.3
1995	59,002 (1,653)	368.8	14.7
1994	14,743 (1,966)	92.1	3.1
1993	10,511 (640)	65.7	0.8
1992	3,009 (539)	18.8	2.5

[a] Confidence limits not calculated—single transect estimate.

Table 7. Estimated 2011 *O. nerka* abundance, density (fish/ha), and biomass (kg/ha) by age class in Redfish, Alturas, and Pettit lakes.

	Age-0	Age-1	Age-2	Age-3	Age-4	Total
Redfish Lake (615 surface ha)						
No. captured	36	1	0	0	0	37
Mean length (mm) (±95 CI)	54.2	106	NA	NA	NA	55.56
Mean weight (g) (±95 CI)	1.34	10.1	NA	NA	NA	1.57
Abundance	42,502	1,169	NA	NA	NA	43,671
95% CI High	62,064	4,173	NA	NA	NA	62,301
95% CI Low	22,940	0	NA	NA	NA	25,041
Density (fish/ha)	69.1	1.90	NA	NA	NA	71.0
Biomass (kg/ha)	0.14	0.03	NA	NA	NA	0.11
Alturas Lake (338 surface ha)						
No. captured	75	5	0	1	0	81
Mean length (mm) (±95 CI)	50.5	80.2	NA	215	NA	54.4
Mean weight (g) (±95 CI)	1.06	4.7	NA	94.7	NA	2.43
Abundance	44,125	3,004	NA	609	NA	47,739
95% CI High	73,739	7,377	NA	2,175	NA	79,259
95% CI Low	14,511	0	NA	0	NA	16,219
Density (fish/ha)	130.54	8.88	NA	1.8	NA	141.2
Biomass (kg/ha)	0.09	0.03	NA	0.17	NA	0.29
Pettit Lake (160 surface ha)						
No. captured	3	4	0	0	0	7
Mean length (mm) (±95 CI)	50.3	116.5	NA	NA	NA	88.14
Mean weight (g) (±95 CI)	1.2	17.4	NA	NA	NA	10.46
Abundance	1,598	2,135	NA	NA	NA	3,733
95% CI High	3,434	6,206	NA	NA	NA	7,040
95% CI Low	0	0	NA	NA	NA	426
Density (fish/ha)	9.98	13.3	NA	NA	NA	23.3
Biomass (kg/ha)	0.01	0.23	NA	NA	NA	0.24

Table 8. Estimated kokanee escapement to Fishhook Creek 1991 to 2011 and Alturas Lake Creek 1992 to 2011. Data obtained from the Shoshone-Bannock Tribes.

Year	Fishhook Creek	Alturas Lake Creek
1991	7,200	No survey data
1992	9,600	60
1993	10,800	200
1994	9,200	3,200
1995	7,000	1,600
1996	10,662	744
1997	8,572	8,492
1998	6,149	15,237
1999	2,336	8,334
2000	60	827
2001	5,853	145
2002	8,626	99
2003	9,679	48
2004	1,508	7,101
2005	4,375	11,652
2006	14,021	2,276
2007	11,235	519
2008	4,908	10,312
2009	1,796	1,627
2010	1,708	4,927
2011	2,545	14,469

Table 9. Estimated angler effort on Redfish Lake for the 2011 fishing season.

Redfish Lake	Boat	Bank	Tube	Total
Estimated Hours fished	2,460	623	0	3,083
± 95%	1,304	448	0	1,468

Table 10. Historical kokanee catch rates, kokanee harvest estimates, bull trout catch rates, and angler effort for the Redfish Lake fishery.

	Kokanee Catch Rates (Fish/Hour)					
	Harvested (Fish/Hour)	Released (Fish/Hour)	Kokanee Harvested	Bull Trout Catch Rate (Fish/Hr)	Angler Parties Interviewed	Estimated Hours Fished/Season
1996	0.19	0.08	844	0.09	107	3,351
1997	0.19	0.37	466	0.08	117	2,874
1998	0.13	0.17	1,362	0.08	205	7,963
1999	0.38	0.15	1,187	0.28	227	3,951
2000	0.02	0.06	67	0.08	63	3,063
2001	0.00	0.06	0	0.27	88	2,391
2002	0.09	0.16	129	0.16	100	2,127
2003	0.10	0.05	424	0.24	98	2,477
2004	0.13	0.26	621	0.31	96	2,791
2005	0.21	0.09	637	0.09	85	3,620
2006	0.07	0.24	222	0.35	131	2,635
2007	0.03	0.09	56	0.12	53	1,922
2008	0.05	0.04	106	0.08	41	2,424
2009	0.00	0.00	0.00	0.55	32	1,219
2010	0.02	0.00	57	0.73	58	2,816
2011	0.00	0.00	0	0.48	48	3,083

Table 11. Catch rates (fish/hour) for summer 2011 on Redfish Lake categorized by day type and species.

	Kokanee		Cutthroat Trout		Bull Trout		All Fish	
Day Type	Kept	Released	Kept	Released	Kept	Released	Kept	Released
Weekday	0.00	0.00	0.00	0.43	0.00	0.73	0.00	1.26
Weekend day	0.00	0.00	0.00	0.00	0.00	0.17	0.05	0.19
Season Avg.	0.00	0.00	0.00	0.24	0.00	0.48	0.02	0.79

Table 12. Estimated number of fish harvested and released on Redfish Lake during summer 2011.

Redfish Lake	Kokanee	Cutthroat Trout	Bull Trout	Other	All Fish ± 95% CI
Harvested	0	0.00	0	67	67
Released	0	746	1,490	213	2,449 ± 2,518

Table 13. Estimated *O. nerka* harvest in Redfish Lake kokanee fisheries, numbers of adipose-clipped hatchery sockeye juveniles caught and released, % ESA-listed sockeye in harvest, and incidental mortality of ESA-listed *O. nerka*, 1997-2011.

Year	*O. nerka* harvest	Population Estimate*	Exploitation Rate*	Ad-clipped hatchery sockeye released	% ESA-listed in harvest	Incidental mortality of ESA-listed sockeye
1997	866	55,762	1.55%	0	1.0%	9
1998	1362	31,486	4.33%	0	1.0%	14
1999	1187	42,916	2.77%	0	1.0%	12
2000	67	10,268	0.65%	0	0.8%	1
2001	0	12,980	0.00%	0	0.0%	0
2002	129	50,204	0.26%	0	0.8%	1
2003	424	81,727	0.52%	5	0.3%	1
2004	621	82,258	0.75%	10	0.3%	2
2005	785	56,220	1.40%	0	0.3%	4
2006	222	82,796	0.27%	0	0.3%	3
2007	56	73,702	0.08%	0	14.0%	8
2008	106	26,284	0.40%	0	13.0%	14
2009	0	28,923	0.00%	0	0.0%	0
2010	57	30,194	0.19%	0	13.5%	8
2011	0	43,671	0.00%	0	0.0%	0

* Simple calculation of population estimate/# harvested

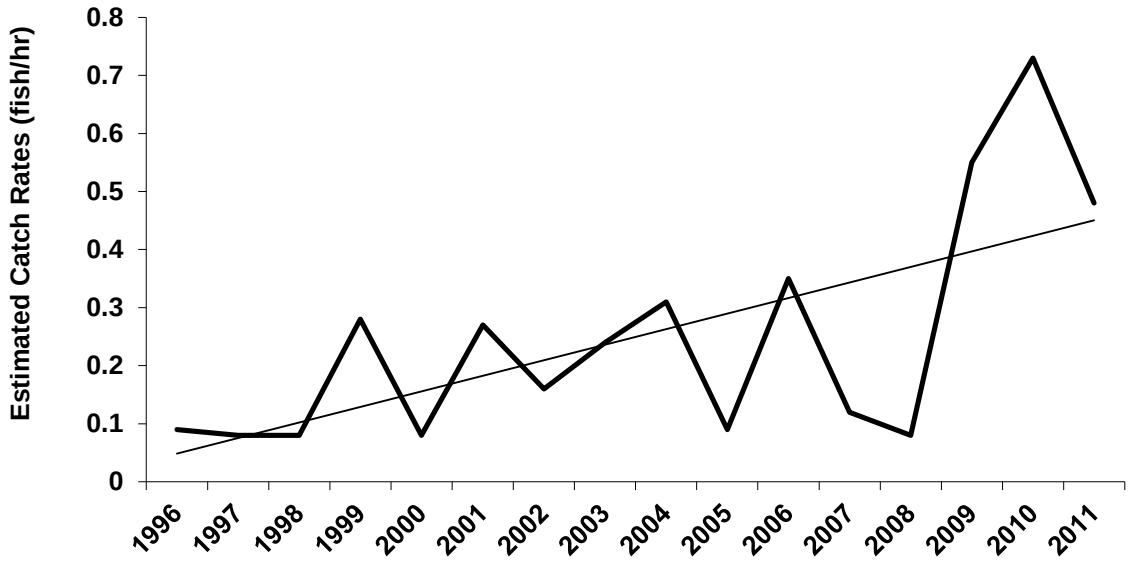

Figure 2. Bull trout catch rates derived from creel data between 1996-2011 within Redfish Lake. The trend line is used to show the catch rate increase within the lake. The equation for the trend line is $y = 0.0268x + 0.0218$ with an R^2 of 0.42.

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PART 3—SOCKEYE SALMON JUVENILE OUT-MIGRANT AND ADULT SPAWNING MONITORING AND EVALUATION

INTRODUCTION

SOCKEYE SALMON JUVENILE OUT-MIGRANT MONITORING AND EVALUATION

Monitoring overwinter survival and out-migration of sockeye salmon smolts plays an important role in restoration efforts. Trapping conducted on the lake outlet streams provides information on timing of out-migration and smolt sizes. Out-migrant monitoring provides an opportunity to monitor natural production of sockeye salmon in the lakes and to evaluate the success of different release strategies. This information allows us to make informed decisions regarding the placement of future captive broodstock progeny.

Out-migrant trapping also provides overwinter survival information for presmolts (fall direct-release) released into the nursery lakes in October the year prior to out-migrant trapping. Hatchery origin sockeye salmon smolts captured at lake out-migrant traps originated primarily from the October 2010 release of adipose fin-clipped presmolts numbering 31,413 sockeye, 16,363 sockeye, and 18,075 sockeye to Redfish, Alturas, and Pettit lakes, respectively (Table 14). Presmolts released in 2010 into Redfish and Pettit lakes were reared at Sawtooth Fish Hatchery (SFH), and presmolts released into Alturas Lake were reared at the Eagle Fish Hatchery (EFH).

ADULT SPAWNING MONITORING AND EVALUATION

Releasing mature adult sockeye salmon into Sawtooth Valley lakes has been an important part of the "spread-the-risk" philosophy of the SBSTOC. Prespawn sockeye salmon adults were first released back to the wild in 1993. Adult sockeye salmon raised to maturity in the hatchery and released to valley lakes to spawn provide a “natural” smolt component that is subject to natural selection. Beginning in 1999, anadromous sockeye salmon have been released into valley lakes (when available) along with adult sockeye salmon that were raised to maturity in a hatchery. Currently, captively reared and anadromous prespawn adults are released only to Redfish Lake.

Success of releasing adults to spawn naturally is evaluated by determining if there is a corresponding increase in production in the number of natural smolts out-migrating and observed egg-to-smolt survival (within Redfish Lake currently). Natural out-migrants can be progeny of residual sockeye salmon adults that spawn in basin lakes; hatchery origin prespawn adults released to the lakes for natural spawning (Redfish Lake only); anadromous adults released to the lakes for natural spawning (Redfish Lake only); eyed egg releases (Alturas or Pettit Lakes); or misclipped hatchery origin smolts. Juvenile kokanee (nonanadromous) could also “fall out” of nursery lakes and contribute to adult trap counts. The weirs on Redfish Lake Creek and Pettit Lake Creek and the screw trap on Alturas Lake Creek enable us to monitor and estimate natural out-migrating smolts and obtain genetic samples.

Current evaluations of adult sockeye salmon releases focus on the number of redds produced, estimations of natural juvenile out-migrants and collection of genetic material for future DNA parental analysis.

METHODS

SOCKEYE SALMON JUVENILE OUT-MIGRANT MONITORING AND EVALUATION

Redfish Lake Creek Trap

The out-migrant trap on Redfish Lake Creek (RLCTRP) is located 1.4 km downstream from the lake outlet at a permanent weir site. The trap functions as a juvenile trap for out-migrating fish, and with minor modifications, as a trap for returning adults (Craddock 1958; Bjornn et al. 1968; Kline 1994; Kline and Younk 1995; Kline and Lamansky 1997; Hebdon et al. 2000, 2002, 2003; Willard et al. 2004, 2005; Peterson et al. 2008, 2010, 2012). The trap was operated from April 7 through June 25, 2011 and contains nine bays, five of which were fitted with incline bar traps. IDFG staff checked the trap twice daily in 2011. The trap is fished until high water forces us to remove it, until fish stop emigrating from the lake, or until mid-June (contract deadline for removal of trap and the placement of the adult trap).

Each fishing bay was fitted with an adjustable 1.70 m wide by 1.74 m long aluminum trap box on a winch and pulley system. The trap boxes were constructed of 3 mm aluminum sheeting and framework and 1.9 cm diameter hollow aluminum bars. The 30.5 cm x 169.5 cm x 30.5 cm live wells were also constructed of 3 mm aluminum with 5 mm holes drilled for aeration and water exchange in the live well. Bar spacing (19 mm) allowed debris and large fish to pass downstream, while low velocity water swept *O. nerka* smolts across the bars and into the live well for holding until personnel were able to empty the trap (Kline 1994).

All sockeye salmon smolts captured at RLCTRP were anesthetized in buffered tricaine methanesulfonate (MS-222; 50 mg/L), measured for fork length (1 mm), weight (0.1 g), and scanned for PIT tags. Scales were removed from a subsample of natural origin and adipose fin-clipped hatchery reared *O. nerka* (five per 5 mm length group) and returned to the laboratory for aging. In the lab, scales were pressed between microscope slides, two program employees individually aged the scales, and a third person aged the discrepancies. The proportions of age-1 and age-2 out-migrants were determined by using the MIX computer program developed by MacDonald and Green (1988). MIX software uses known values (the scale ages in this case) and fits mixture distributions to grouped data by utilizing a maximum likelihood estimator. All captured nontarget species were counted and released immediately. Fin-clip samples were taken from up to 50 natural smolts/day for future genetic analyses (Redfish Lake = 1,271, Alturas Lake = 0, Pettit Lake = 201).

To estimate trapping efficiency, up to 50 natural origin sockeye salmon smolts (determined by presence of an adipose fin) and 50 hatchery origin sockeye salmon smolts were PIT tagged daily and released approximately 250 m upstream of the weir one-half hour after sunset. All remaining fish were identified (natural origin and hatchery origin), scanned for PIT tags, counted, and released 15 m below the weir one-half hour after sunset. Flow-through live boxes with locking lids were used to hold fish until the evening release. Trapping efficiencies were calculated for natural origin sockeye salmon smolts and fall direct-released sockeye salmon smolts. Intervals were selected based on stream discharge similarities and the number of PIT-tagged smolts released upstream of the weir that were available for recapture (trap efficiencies). Natural origin fish typically out-migrate earlier in the season than fall direct-release fish (Figure 3). Hatchery-produced sockeye salmon smolts captured at the trap originated primarily from the 31,413 BY09 adipose fin-clipped presmolts (reared at SFH) released into the lake in October 2010 (Table 4). Stream velocity was measured below the trap weekly. Out-migrant run size was derived using a modified Bailey estimator and 95% bootstrap confidence

intervals using methods described by Steinhorst et al. (2004). Smolt out-migration estimates were calculated separately for natural origin and fall direct-released hatchery origin sockeye salmon smolts. During the spring of 2011, we experienced normal flow conditions throughout the trapping season.

Alturas Lake Creek Trap

Sockeye salmon out-migrant trapping and PIT tagging on Alturas Lake Creek was conducted by the SBT. The Alturas Lake Creek screw trap is located 13 km downstream from the Alturas Lake outlet and was operated from April 13 to June 13, 2011. Hatchery-produced sockeye salmon smolts captured at the trap originated primarily from 16,363 adipose fin-clipped presmolts (reared at EFH) released into the lake in July 2010 (Table 4). The Alturas Lake out-migrant population estimate was derived using the same estimator described above (Steinhorst et al. 2004). Activities conducted by the Shoshone-Bannock Tribes are reported under separate cover.

Pettit Lake Creek Trap

Sockeye salmon out-migrant trapping and PIT tagging on Pettit Lake Creek was conducted by the SBT. The Pettit Lake Creek trap is located 1 km downstream from the Pettit Lake outlet at a permanent weir site and was operated from April 13 to June 13, 2011. Hatchery-produced sockeye salmon smolts captured at the trap originated primarily from the 18,075 adipose fin-clipped presmolts (reared at SFH) released into the lake in October 2010 (Table 4). The Pettit Lake Creek weir traps at 100% efficiency under low spring flow conditions (D. Taki, Shoshone Bannock Tribes, personal communication); therefore, out-migration run size for Pettit Lake is based on the census number of smolts trapped. However, during normal to high flow years, the trap must be removed and other means are used to estimate the number of out-migrants. Activities conducted by the Shoshone-Bannock Tribes are reported under separate cover.

Redfish Lake Creek Smolt Groups

A total of 191,048 BY09 smolts were released immediately below the Redfish Lake Creek Trap (Table 14). This release included smolts reared at the MRS, SFH and OFH. All smolts released from SFH and OFH were coded-wire-tagged, with a representative group (n = 63,091) PIT tagged.

Main Stem Snake and Columbia River Dams

In 2011, sockeye salmon smolts were transported (if collected in juvenile facilities within the hydrosystem corridor) and released below Bonneville Dam according to a USACE PIT tag study (methods and results can be found in BioMark and Quantitative Consultants, Inc. 2010). As a result, migration corridor survival evaluations were only conducted to Lower Granite Dam (LGR) for this project. Sockeye salmon smolt survival to LGR was evaluated using PIT tag interrogation data collected at PIT tag detection facilities throughout the Snake and Columbia rivers. Interrogation data were retrieved from the PIT tag information system (PTAGIS) maintained by the Pacific States Marine Fisheries Commission (Portland, Oregon). This data was used to develop SURPH survival estimates to LGR. The SURPH model uses PIT tag detections at various dams to develop a Cormack/Jolly-Seber estimate of survival to LGR. Total natural origin and hatchery origin smolt out-migration (for each lake and different release strategy) to LGR was estimated using the SURPH survival estimate (for each respective release

group) multiplied by the out-migration estimate of each release group at the out-migration trap sites found in the Stanley basin (Table 14).

ADULT SPAWNING MONITORING AND EVALUATION

Sockeye Salmon Spawning Investigations

Between August 17 and October 14, 2011, 1,548 adult sockeye salmon were released to Redfish Lake (Table 5). Adult releases included 990 anadromous return adults, 230 adults raised at NOAA Burley Creek Hatchery, and 328 EFH adult fish. Sex was determined by ultrasound for hatchery adults.

In order to assist in identifying spawning locations, ten male and ten female (five of each sex implanted in anadromous returns and five of each sex implanted in hatchery-produced) sockeye salmon were fitted with gastric implant radio transmitters prior to release. Telemetry investigations of adult locations began September 18, 2011 and continued weekly through November 2, 2011. Fish locations were recorded weekly by tracking movements via powerboat.

Redd counts were also conducted once a week (coinciding with radio telemetry events) beginning on October 20, 2011 and continuing until November 2, 2011. Suspected redds were generally enumerated by two observers on each count date. On the final count date, three observers were used. Areas of excavation (possible redds) were generally 3 m x 3 m in size and likely represented spawning events by multiple parents. As such, we do not know how many parents contributed to the production of natural progeny in spawn year 2011. During redd count surveys any observed carcasses that could be retrieved were collected to facilitate the collection of biological information (e.g., fish sex and spawning status). We also performed redd counts on Fishhook Creek, Redfish Lake Creek, the Salmon River between Sawtooth Fish Hatchery and the mouth of Redfish Lake Creek, Valley Creek, and Little Redfish Lake in 2011.

Natural Origin Juvenile Out-migrant Monitoring

In 2011, natural origin out-migrants produced from program fish releases to Redfish Lake included: 1) age-1 out-migrants produced from 1,349 adults released for volitional spawning in 2009, and 2) age-2 out-migrants produced from 969 hatchery-origin adults released in 2008. Any age-1 natural origin out-migrants found within Alturas Lake could have been produced by residual sockeye or kokanee or 15,568 eyed sockeye eggs released in 2009. Any age-2 natural origin out-migrants found within Alturas Lake would have been produced from residual sockeye or kokanee. Natural origin out-migrants produced from program fish releases to Pettit Lake included age-1 out-migrants produced from 59,511 eyed eggs released in 2009, age-2 out-migrants from 67,984 eyed eggs released in 2008 or residual adults from either year. The proportions of age-1 and age-2 unmarked emigrants were determined for 2011 Redfish, Alturas, and Pettit lake out-migrants by aging scales. The methods for this analysis are discussed above.

Adult Trapping on Redfish Lake Creek

The adult weir on Redfish Lake Creek captures all upstream migrating sockeye salmon and bull trout. Trapping in Redfish Lake Creek for adult migrants started on July 22 and continued until October 14, 2011. During the operation of the adult sockeye salmon weir on

Redfish Lake Creek in 2011, 542 adult anadromous sockeye and 128 adult bull trout were captured.

RESULTS AND DISCUSSION

SOCKEYE SALMON JUVENILE OUT-MIGRANT MONITORING AND EVALUATION

Redfish Lake Creek Trap

A total of 4,274 sockeye salmon smolts (2,612 natural origin and 1,662 hatchery origin) were trapped during the 2011 out-migration season (Figure 3 and Table 15). Fork length of natural origin and hatchery origin sockeye salmon smolts captured averaged 108.5 mm (range 89 mm to 178 mm; Figure 4) and 103.1 mm (range 84 mm to 163 mm; Figure 4), respectively. Sockeye salmon smolt lengths were slightly shorter for natural origin smolts and slightly longer for hatchery origin smolts in 2011 than during the 2010 out-migration season (Peterson et al. 2012).

Based on observed trapping efficiencies and discharge during out-migration monitoring, we determined that using three trapping interval for the natural origin smolts was appropriate for estimating total natural origin sockeye salmon smolt out-migration. Of the 2,612 natural origin smolts handled in 2011, 1,308 were marked and released upstream of the weir to estimate trapping efficiency (Table 15).

Trap efficiency decreased from a five-year average (2001-2005) of 42% to 32% during 2011. This was likely due to predation at the trap by small mammals, piscivorous birds, bull trout or due to the high flows observed. Predation of released smolts continued to be observed during 2011. Several personnel visually observed hooded mergansers and bull trout harassing juvenile sockeye at the trap. Predation above the trap on released fish causes an artificial decrease in trap efficiency that would have caused us to overestimate the number of natural out-migrants. During 2011, we continued our capture and haul program to remove bull trout from the juvenile trap site so we could develop better out-migration estimates at the Redfish Lake Creek trap.

The 2011 total natural origin sockeye smolt out-migration was estimated at 6,879 fish (95% CI 6,144-7,748; Table 15). The proportion of age-1 natural origin smolts was estimated at 96.7%, which equals 6,652 smolts; the proportion of age-2 natural origin smolts was estimated at 3.3%, which equals 227 smolts. As referenced in the Methods section of this report, age proportions were estimated using the MIX software application.

Of the 1,662 fall direct-released smolts handled in 2011, 1,189 were marked and released upstream of the weir to estimate trap efficiency. Total fall direct-released smolt out-migration was estimated at 5,236 fish (95% CI 4,569–6,043; Table 15). Overwinter survival and out-migration for this group was 17% of the number of presmolts planted in 2010 (Table 16). The proportion of age-1, adipose fin-clipped, hatchery-reared smolts was estimated at 99.4%, which equals 5,205 smolts; the proportion of age-2, adipose fin-clipped, hatchery-reared smolts was estimated at 0.6%, which equals 31 smolts.

Alturas Lake Creek Trap

A total of 66 sockeye salmon smolts (2 natural origin and 64 hatchery origin) were PIT tagged during the 2011 out-migration season. Fork length of natural origin and fall direct-

released sockeye salmon smolts captured averaged 101 mm (range 98 mm to 104 mm) and 115 mm (range 95 mm to 201 mm), respectively. The average size of out-migrating sockeye smolts was similar to 2010 (Peterson et al. 2012).

Total natural origin sockeye smolt out-migration for Alturas Lake was estimated at 19 fish (95% CI not calculated), and hatchery origin smolt out-migration was estimated at 923 fish (95% CI 719–1,079; see SBT annual report for methods and calculations; Table 14). Genetic samples were not collected from out-migrating sockeye smolts due to the very low number detected. Overwinter survival and estimated outmigration for the fall direct-release group was 6% of the number of presmolts planted in 2010 (Table 16). Scales for aging were also not collected from natural origin smolts at the Alturas Lake Creek trap in 2011, due to the limited number of out-migrants. Therefore, we were not able to estimate the age proportion of natural origin and hatchery origin sockeye smolts for Alturas Lake in 2011.

Pettit Lake Creek Trap

Total natural origin sockeye smolt out-migration for Pettit Lake in 2011 was estimated at 11,890 fish and hatchery origin smolt out-migration was estimated at 2,745 fish; see SBT annual report for methods and calculations; Table 14). Overwinter survival and out-migration for fall 2010 direct-released presmolts was 15% (Table 16). Fork length of natural origin and fall direct-released sockeye salmon smolts captured averaged 118 mm (range 97 mm to 182 mm) and 111 mm (range 90 mm to 179 mm), respectively. Scales for aging were not collected from natural or hatchery origin smolts at the Pettit Lake Creek trap in 2011, therefore, we did not estimate the age proportions of these groups during the 2011 trapping season.

Salmon River and Redfish Lake Creek Smolt Groups

We released 191,048 BY09 smolts into Redfish Lake Creek below the out-migrant weir on May 12, 2011. This release group consisted of smolts reared at the OFH (n = 54,761), MRS (n = 673), and SFH (n = 135,614). All fish released were coded-wire-tagged with a representative group (n = 63,091) PIT tagged. SFH smolts had an average fork length of 83.1 mm (range 63 mm to 102 mm) and an average weight of 5.4 g/fish. The smolts of OFH averaged 148 mm (range 105 mm to 183 mm) in fork length and had an average weight of 32.4 g/fish.

Main Stem Snake and Columbia River Dams

We estimated smolt out-migration success to LGR for natural origin and hatchery origin sockeye salmon smolt groups using PIT tag interrogation data (Table 14; Appendix B). Estimates reflect numbers of smolts that arrived at LGR based on results from data analyses using the SURPH model (Table 14). Survival among release groups ranged from a low of 32.0% (Pettit Lake presmolts) to a high of 78.2% (MRS smolts). The average survival rate for all the release groups was 56.6% to LGR (up from 27% average survival in 2010; Peterson et al. 2012). An estimated 2,863 (39% survival) and 2,618 (50% survival) natural origin and fall direct-release sockeye smolts, respectively, survived to LGR from the Redfish Lake Creek trap. Survival from the Alturas Lake Creek trap to LGR was not estimated due to low recapture rates for natural origin smolts and 604 (65.4% survival) for fall direct-release smolts. Survival from the Pettit Lake Creek trap to LGR was estimated at 4,518 (38% survival) for natural origin smolts and 878 (32% survival) for fall direct-release smolts. An estimated 526 (78.2% survival) MRS smolts, 42,221 (77.1% survival) smolts from OFH and 98,727 (72.8% survival) SFH sockeye smolts survived to LGR from the Redfish Lake Creek smolt release groups. The total estimate for sockeye smolts that out-migrated from Stanley basin waters and survived to LGR for 2011

was 152,775 (Table 14). This was the sixth year we used the SURPH model to estimate survival and numbers of smolts to LGR. We will continue to utilize the SURPH model to develop survival and total estimates to LGR.

SOCKEYE SALMON SPAWNING INVESTIGATIONS AND NATURAL ORIGIN JUVENILE OUT-MIGRANT MONITORING

Sockeye Salmon Spawning Investigations

A total of 1,548 prespawn adult sockeye (558 full-term captive reared and 990 anadromous return) salmon were released into Redfish Lake in 2011. The first redd was observed near the "transfer dock" (see Figure 5) at Redfish Lake on September 20, 2011. Redd counts were finalized with three observers in one boat on November 02. Redd construction timing was similar to observations made in the past (Plaster et al. 2007; , Peterson et al. 2008, 2010, 2012). During the final counts, 385 redds (areas of excavation) were identified (Table 17). We observed 74 redds located near the U.S. Forest Service Transfer dock, 85 redds located on the beach southeast of the Redfish Lake Creek inlet, 203 redds within the southern snorkel transect area, and 23 redds at Sockeye Beach (Table 17; Figure 5). This count is higher than the 2010 count of 155 suspected redds (Peterson et al. 2012). Areas of excavation (possible redds) are typically large (~3 m x 3 m) and may represent multiple spawning events by multiple parents; therefore, we do not know how many parents contributed to potential natural production in 2011. Radio-tagged fish moved to areas where redds were observed, and carcasses were recovered (when possible) to verify spawning.

Radio telemetry data also assisted with collecting information on additional spawning locations during 2011. We observed a total of 4 redds in Little Redfish Lake, 13 sockeye redds between Redfish Lake and the confluence of Redfish Lake creek and the Salmon River, 5 sockeye redds in the Salmon River between the mouth of Redfish Lake Creek and the Sawtooth Fish Hatchery; and 9 sockeye salmon redds were counted in Fishhook Creek in 2011. We did not observe any redds in Valley Creek from the mouth of the Salmon River to the confluence of Stanley Lake Creek during 2011.

Natural Origin Juvenile Out-migrant Monitoring

In 2011, 6,879 natural origin smolts (95% CI 6,144 to 7,748) were estimated to have out-migrated from Redfish Lake (Table 14), 19 unmarked smolts were estimated to have out-migrated from Alturas Lake, and 11,890 unmarked smolts were estimated to have out-migrated from Pettit Lake (Table 14, Figure 6). While the SBSTOC believes it is important to utilize reintroduction strategies that produce natural origin smolts (e.g., prespawn adult releases and eyed-egg introductions), it is important to note the difficulty in evaluating the effectiveness of these release strategies in the presence of kokanee and potentially increasing residual populations within the basin lakes. To address these issues, beginning in 2005, we started working with the Idaho Department of Fish and Game's Eagle Fish Genetics Laboratory to utilize DNA microsatellite methodologies to identify individual parental contribution to natural origin smolt production through parental analysis. Parental analysis allows assignment of an individual smolt to parents of a release strategy, allowing comparisons between the relative individual contribution of adults released to spawn volitionally and survival comparisons to certain life history stages (e.g., green egg-to-smolt and/or fry-to-smolt survival) for various release strategies. Results would allow program managers to emphasize the release strategy with the highest reproduction potential. Additionally, parental analysis will allow for evaluation of

the reproductive contribution of residuals and estimation of the number of kokanee that emigrate from basin lakes. We have tested the assignments of juveniles from known adult crosses to see how well they assign and have determined that we are able to employ these techniques to samples collected in the field (C. Kozfkay, IDFG, personal communication). We have started analyzing out-migrants from 2010 and will analyze 2011 natural origin out-migrants to answer genetic evaluation questions relating to the various release strategies and the contribution of residual production to this population.

Table 14. Summary of 2011 sockeye salmon smolt out-migration information (by release strategy) at trap locations and at Lower Granite Dam (LGR). Sawtooth Fish Hatchery (SFH) was the rearing location for the fall direct released (FDR) presmolts and smolt release group. Oxbow Fish Hatchery (OFH) and the Manchester Research Station (MRS) were the rearing locations for other smolt releases.

Release strategy (rearing location)	Total released[a]	Number tagged prior to release	PIT tags detected at trap	Smolt out-migration estimate	Number tagged at trap	Estimated SURPH survival at LGR	SURPH[c] 95% CI (±)	Estimated no. at LGR
Redfish Lake								
Natural origin smolt	NA	NA	NA	6,879	1,308	39.00%	6.30%	2,683
FDR presmolt (SFH)	31,413	NA	NA	5,236	1,189	50.00%	5.60%	2,618
Alturas Lake[b]								
Natural origin smolt	NA	NA	NA	19	2	NA	NA	NA
FDR presmolt (SFH)	16,363	1,018	7	923	66	65.40%	31.70%	604
Pettit Lake[b]								
Natural origin smolt	NA	NA	NA	11,890	413	38.00%	22.00%	4,518
FDR presmolt (SFH)	18,075	NA	5	2,745	126	32.00%	22.00%	878
Redfish Lake Creek								
Hatchery origin smolt (MRS)	673	673	NA	673	NA	78.20%	20.80%	526
Hatchery origin smolt (OFH)	54,761	9,973	NA	54,761	NA	77.10%	4.20%	42,221
Hatchery origin smolt (SFH)	135,614	51,672	NA	135,614	NA	72.80%	1.40%	98,727

[a] Total released from hatchery; presmolts = 2010, smolts = 2011.
[b] Data from Alturas and Pettit lake trap obtained from Shoshone-Bannock Tribes biologists.
[c] 95% CIs are two standard errors.

Table 15. Out-migration estimate for natural and hatchery origin sockeye salmon smolts captured at the Redfish Lake Creek trap from April 7 to June 25, 2011.

Natural Origin smolts (three interval estimate)				
	Interval 1	Interval 2	Interval 3	Total
Dates	4/7-5/17/11	5/18-6/7/11	6/8-6/24/11	4/7-6/25/11
Trap efficiency	0.42	0.37	0.28	
Marked	443	776	89	1,308
Recaptured	188	286	25	499
Total handled	725	1,798	89	2,612
Estimated total	1,703	4,868	308	6,879
95% CI upper bound	1,921	5,382	445	7,748
95% CI lower bound	1,503	4,429	212	6,144

Hatchery origin smolts (three interval estimate)				
	Interval 1	Interval 2	Interval 3	Total
Dates	4/7-5/17/11	5/18-6/7/11	6/8-6/24/11	4/7-6/25/11
Trap efficiency	0.22	0.32	0.30	
Marked	45	898	246	1,189
Recaptured	10	291	73	374
Total handled	46	1,354	262	1,662
Estimated total	192	4,169	875	5,236
95% CI upper bound	337	4,634	1,072	6,043
95% CI lower bound	105	3,759	705	4,569

Table 16. Estimated overwinter out-migration success for Sawtooth Fish Hatchery-reared presmolts released in the summer or fall to Redfish, Alturas, and Pettit lakes.

Out-migration Year	Redfish Lake	Alturas Lake	Pettit Lake
2000	29%	34%	46%
2001	20%	75%	29%
2002	40%	30%	29%
2003	15%	NA	59%
2004	27%	54%	35%
2005	35%	82%	56%
2006	43%	38%	64%
2007	23%	26%	25%
2008	27%	53%	59%
2009	25%	31%	54%
2010	17%	9%	24%
2011	17%	6%	15%

Table 17. Redfish Lake Sockeye Salmon Captive Broodstock Program prespawn adult release history.

Lake	Rearing Origin	Date Released	Number Released	Number of Suspected Redds
Redfish	Full-term hatchery	1993	20	Unknown
Redfish	Full-term hatchery	1994	65	One behavioral observation
Redfish	Full-term hatchery	1996	120	30 suspected redds
Redfish	Full-term hatchery	1997	80	30 suspected redds
Pettit	Full-term hatchery	1997	20	1 suspected redd
Alturas	Full-term hatchery	1997	20	Test digs only
Redfish	Full-term hatchery	1999	18	
Redfish	Hatchery-produced anadromous	1999	3	8 suspected redds
Redfish	Full-term hatchery	2000	46	
Redfish	Hatchery-produced anadromous	2000	120	20 to 30 suspected redds
Pettit	Hatchery-produced anadromous	2000	28	none confirmed
Alturas	Full-term hatchery	2000	25	
Alturas	Hatchery-produced anadromous	2000	52	14 to 19 suspected redds
Redfish	Full-term hatchery	2001	65	12 to 15 suspected redds
Redfish	Hatchery-produced anadromous	2001	14	
Redfish	Full-term hatchery	2002	178	10 to 12 suspected redds
Redfish	Hatchery-produced anadromous	2002	12	
Redfish	Full-term hatchery	2003	315	42 suspected redds
Redfish	Full-term hatchery	2004	241	127 suspected redds
Redfish	Full-term hatchery	2005	173	78 suspected redds
Redfish	Full-term hatchery	2006	464	172 suspected redds
Redfish	Full-term hatchery	2007	494	195 suspected redds
Redfish	Full-term hatchery	2008	398	
Redfish	Hatchery-produced anadromous	2008	571	338 suspected redds
Redfish	Full-term hatchery	2009	682	
	Hatchery-produced anadromous	2009	667	201 suspected redds
Redfish	Full-term hatchery	2010	372	
	Hatchery-produced anadromous	2010	1,210	155 suspected redds
Redfish	Full-term hatchery: Burley Creek	2011	230	385 suspected redds +
	Full-term hatchery: EFH	2011	328	31 additional redds within
	Hatchery-produced anadromous	2011	990	Stanley Basin tributaries
		TOTAL	**8,021**	

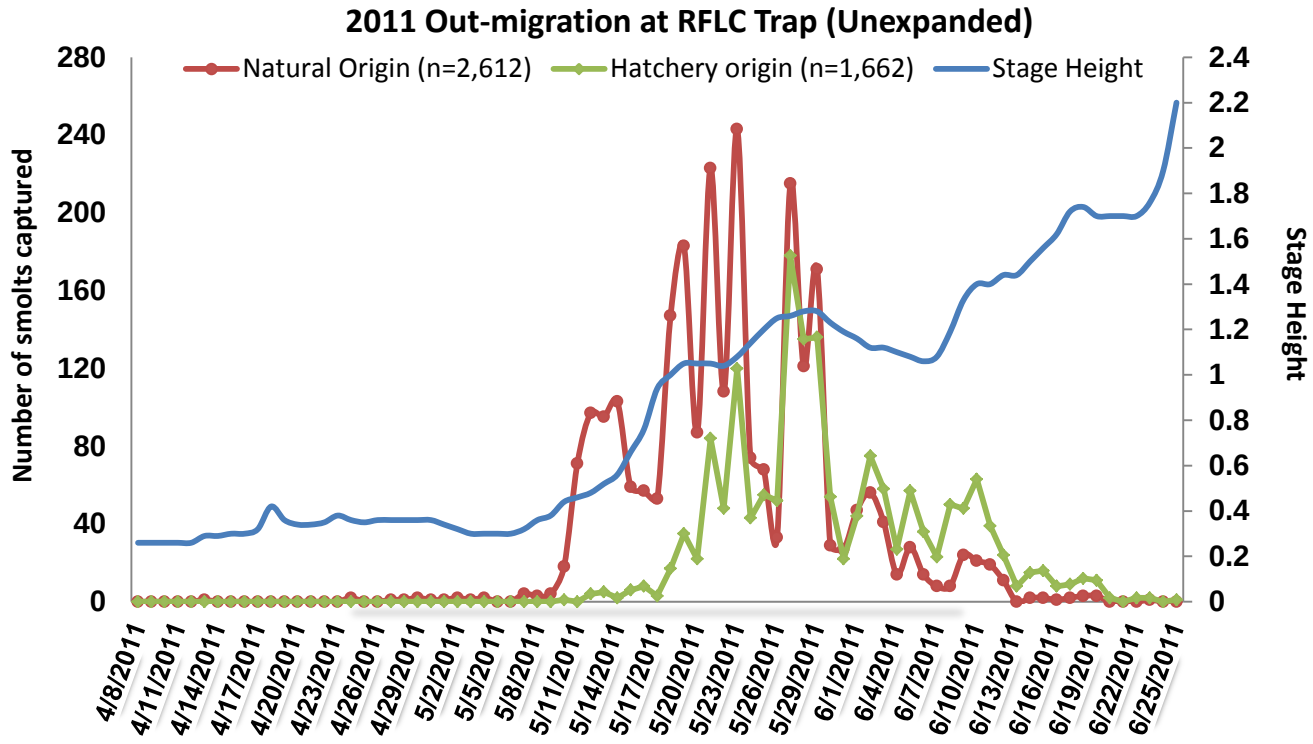

Figure 3. Daily capture of natural origin and hatchery origin sockeye salmon smolts (unexpanded) at the Redfish Lake Creek trap during the 2011 out-migration.

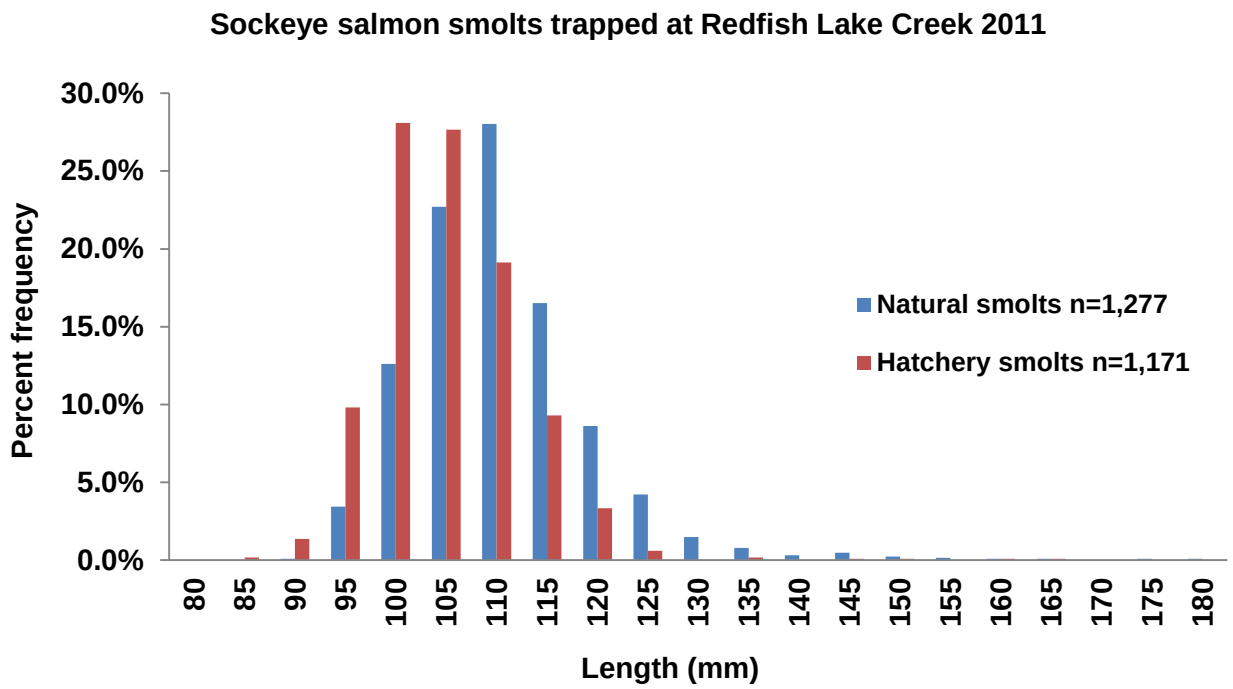

Figure 4. Length frequency of natural (n = 1,277) and hatchery origin (n = 1,171) sockeye salmon smolts collected at Redfish Lake Creek trap in 2011.

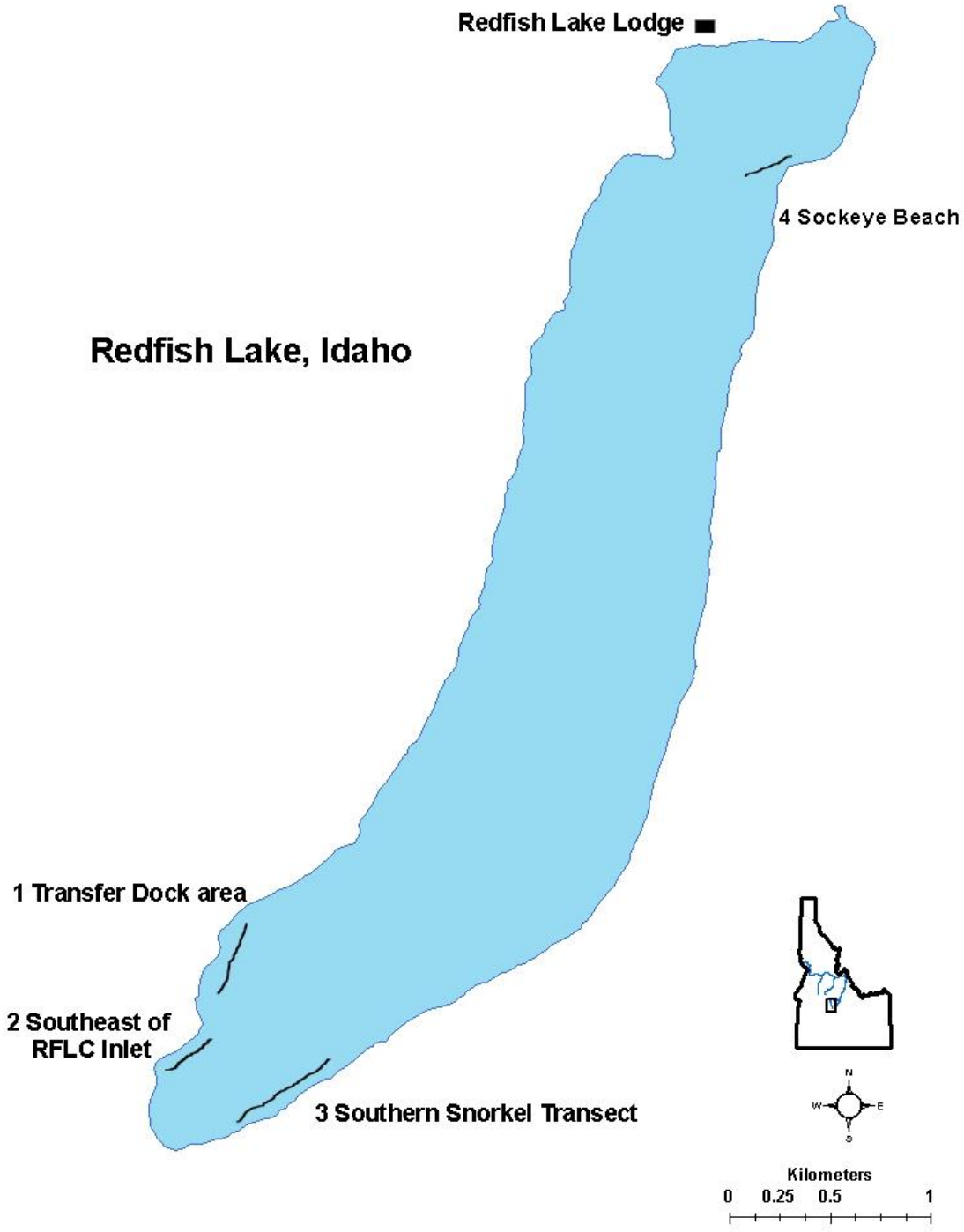

Figure 5. Spawning locations for sockeye salmon in Redfish Lake: 1) area near the U.S. Forest Service transfer camp dock, 2), area southeast of RFLC inlet 3) southern snorkel transect area, and 4) Sockeye Beach.

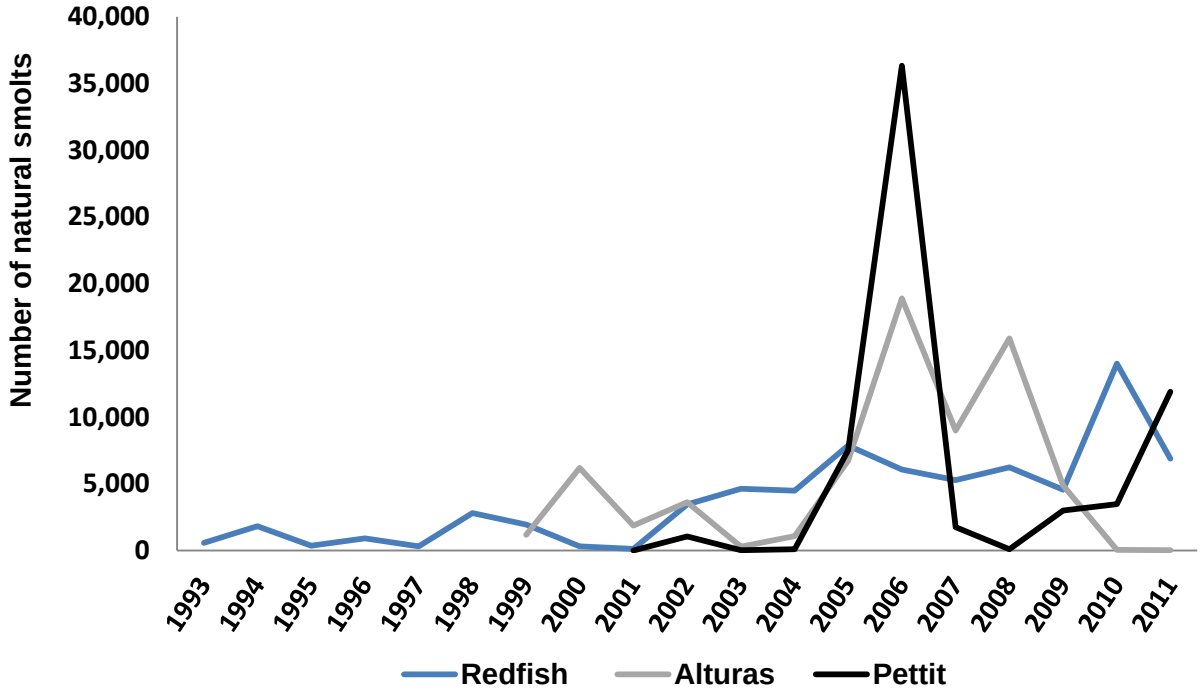

Figure 6. Natural origin sockeye salmon smolt out-migration estimated at Redfish Lake Creek, Alturas Lake Creek, and Pettit Lake Creek traps from 1991 to 2011 (juvenile out-migrant traps on Pettit Lake Creek were not operated every year).

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PART 4—PREDATOR SURVEYS

INTRODUCTION

Declines in bull trout populations throughout the Pacific Northwest led to their listing as threatened under the Endangered Species Act in 1998. Prior to listing, IDFG implemented no-harvest fishing regulations to help protect the remaining populations in the State of Idaho. Because bull trout readily consume kokanee and other salmonids (Bjornn 1961; Beauchamp and Van Tassell 2001), a large increase in the number of adult bull trout in Stanley basin lakes could affect the recovery of sockeye salmon and kokanee populations in the lakes. Bull trout spawner investigations were initiated in 1995 to monitor Redfish and Alturas lakes bull trout populations. Index sections were established on Fishhook and Alpine creeks (tributaries to Redfish Lake and Alturas Lake, respectively) in 1998. Information collected in 2011 represented the 14th year data were collected in these index reaches.

METHODS

In 2011, we surveyed the index reaches of Fishhook Creek and Alpine Creek on August 24 and September 13, 2011 to enumerate bull trout spawners and redds (Figure 7 and 8, respectively). These dates typically correspond with the initiation of spawning (first survey) and the completion of spawning activities and redd construction (second survey). No suitable tributary streams feed Pettit Lake and, as such, bull trout spawner surveys were not conducted on this system. Index sections were established with global positioning satellite (GPS) equipment. Two observers walked from the lower boundary of the index section upstream and recorded visual observations of bull trout and known or suspected bull trout redds. Coordinates of redd locations were recorded with a handheld GPS unit. In order to avoid omission of completed redds during the final count, completed redds identified during the first count were flagged. Flagging prevents omitting redds from the final count that were obscured over time.

In 2007, an additional area was surveyed for bull trout redds in Fishhook Creek (identified as Fishhook Creek lower site). The new section includes the lower portion of Fishhook Creek upstream of the first gradient gain above Redfish Lake and ends at the wilderness boundary located between GPS waypoints 44° 08.889N 114.55.660W, and 44°08.639N 114°57.384W (Figure 7).

Bull Trout Capture, Mark, and Haul Operations Redfish Lake Creek

As mentioned previously in this report (Part 3, page 32), during the out-migration season of 2011, trap efficiency at the juvenile out-migrant sockeye salmon trap on Redfish Lake Creek dropped from a five-year season average of 42% to 32%. The marked decrease in trap efficiency was attributed to avian, mammalian, and fish predation observed by trap tenders. Fish predation was attributed primarily to bull trout keying in on the release of marked sockeye salmon used to measure the trap efficiency. In an attempt to develop accurate juvenile sockeye out-migration estimates with reliable trap efficiencies, IDFG attempted to capture bull trout at Redfish Lake Creek trap using angling methods. Each captured bull trout was scanned prior to tagging for juvenile sockeye salmon PIT tags. If smolt tags were identified, they were recorded and the bull trout received a PIT tag (cheek implants) and was transported four miles downstream from the confluence of Redfish Lake Creek and the Salmon River and released.

The adult sockeye weir on Redfish Lake Creek captures all upstream migrating sockeye salmon and bull trout. Trapping in Redfish Lake Creek for adult migrants started on July 22 and continued until October 14, 2011.

RESULTS AND DISCUSSION

Fishhook Creek

In the upper site trend section of Fishhook Creek, we observed 25 adult bull trout and 8 redds on August 26, 2011. During our second survey on September 13, we observed 3 adult bull trout and 3 new redds (Figure 9) for a total of 11 completed redds. We observed 14 adult bull trout and zero redds on August 24, 2011 in the lower site trend count area on Fishhook Creek. During our second survey on September 13, we observed 3 adult bull trout and a total of 11 complete redds (Figure 10).

During the 14 years of data collection, we have observed fluctuating population trends in the data. The cyclic appearance in the data suggests normal variation within this population. Copeland and Meyers (2011) identified similar patterns within multiple salmonid populations in Idaho during the same period. Redd counts in Fishhook Creek had been stable or slightly increasing since 1998. Our findings are consistent with results from statewide monitoring efforts, which indicate that bull trout are increasing or at least stable across most of their range in Idaho (High et al. 2005). Because bull trout may spawn in alternating or consecutive years (Fraley and Shepard 1989), year-to-year variation would be expected.

Alpine Creek

We observed no adult bull trout and no completed redds on both our August 25, 2011 and September 12, 2011 surveys (Figure 11). We were unable to identify a blockage to upstream migration before the count in 2011. This was the fourth year in a row we observed no fish utilizing the original trend area. Therefore, in addition to the original trend area, we established a second index site below the original area (starting point 44’08.817N 114’55.173W and ending at 43’53.824N 114’54.792W). The Alpine Creek population had increased steadily between 1998 and 2001, followed by a stabilizing period between 2002 and 2007 based on redd count and fish observation data. We have no evidence to believe that the population is collapsing (we observed adults spawning below the original trend area) and suspect that upstream passage is halting the use of the original trend site spawning habitat within Alpine Creek. By establishing the second trend area below the original trend site, we hope to gain additional information about the population and identify whether we are seeing actual population changes. Documentation of significant population changes have been identified from redd count data (Rieman and Meyers 1997).

We believe that our counts of redds in the trend sections were an accurate reflection of the numbers of redds present. The streams in our surveys were much smaller than those used by Dunham et al. (2001), which indicated that redds could be missed in larger systems. For example, in the systems studied by Dunham et al. (2001), deepwater cover was defined as water greater than 1 m deep. In Fishhook and Alpine creeks, water depth rarely approached 1 m deep.

Bull Trout Capture, Mark, and Haul Operations Redfish Lake Creek

We captured 11 adult bull trout at the Redfish Lake Creek trap by hook and line that were PIT tagged and transported to the release location on the main Salmon River. No juvenile sockeye salmon smolt PIT tags were detected in the stomachs of the captured bull trout (Table 18).

During the operation of the adult sockeye salmon weir on Redfish Lake Creek in 2011, 542 adult anadromous sockeye salmon and 128 adult bull trout were handled. A portion of the bull trout that were captured and passed received PIT tags (n = 111). A total of six bull trout mortalities were collected on the upstream side of the weir and are attributed to either angling or post spawn events.

Work done by Schoby (2006) suggests that bull trout in the upper Salmon River migrate from spawning tributaries in early October and that some individuals migrate to Redfish Lake to overwinter. Since 2008, our adult sockeye weir has been operated until mid- to late October, enabling us to collect data on bull trout moving into Redfish Lake to overwinter. The collection of this data should provide us with additional information on how bull trout populations fluctuate in the upper Salmon River drainage and whether predation issues within Redfish Lake are occurring that are not detected by using redd data alone. If increasing numbers of bull trout are migrating into the system to overwinter, we may see predation on *O. nerka* increase within the lake resulting in decreased egg-to-smolt survival as well as lower migration survival during out-migration. With the increase in adult sockeye returns during 2008-2011, we have begun monitoring the egg-to-smolt survival and will continue to monitor the bull trout population to identify changes when possible (Figure 12).

Table 18. Bull trout relocation effort juvenile out-migrant trapping at Redfish Lake Creek, 2011.

Year	Bull Trout Captured, PIT Tagged, Relocated	Bull Trout Recaptured At Trap Site	Bull Trout With *O. Nerka* PIT Tags Detected In Stomach	Bull Trout Mortalities Associated With Transport Activities
2008	18	4	4	0
2009	11	1	0	0
2010	3	0	0	0
2011	11	0	0	0

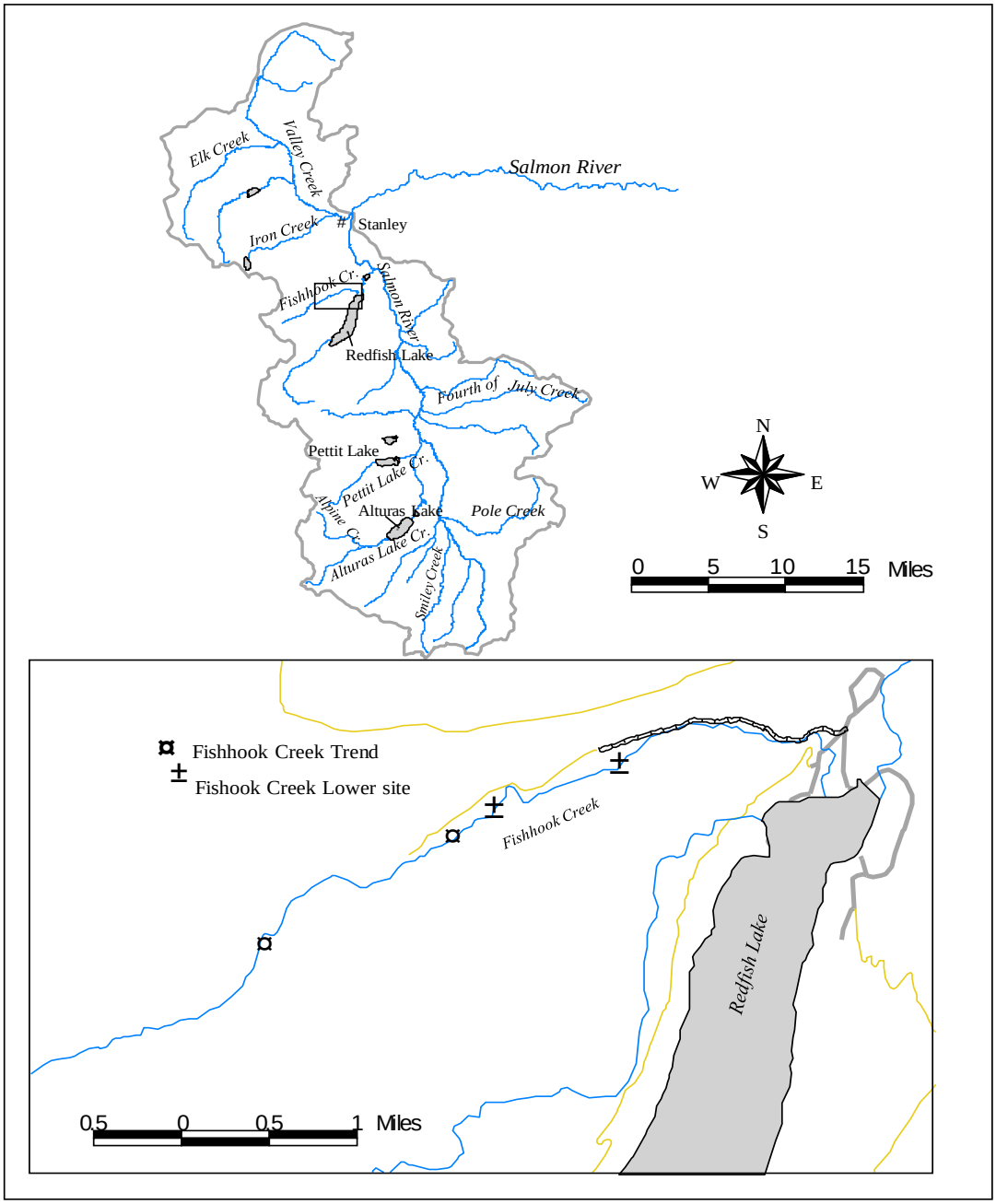

Figure 7. Location of bull trout redd index sections in Fishhook Creek in 2011.

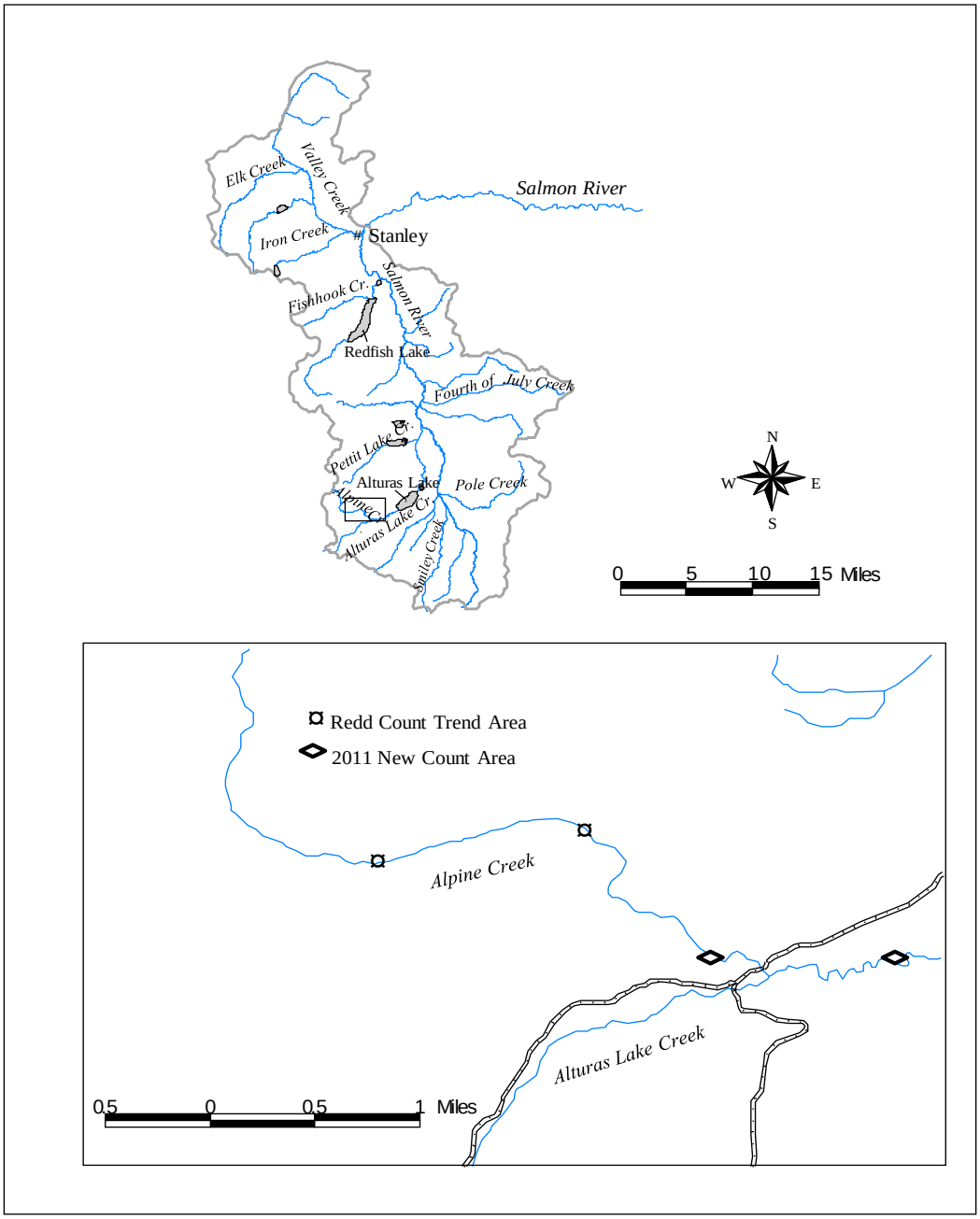

Figure 8. Location of bull trout redd index sections in Alpine Creek in 2011.

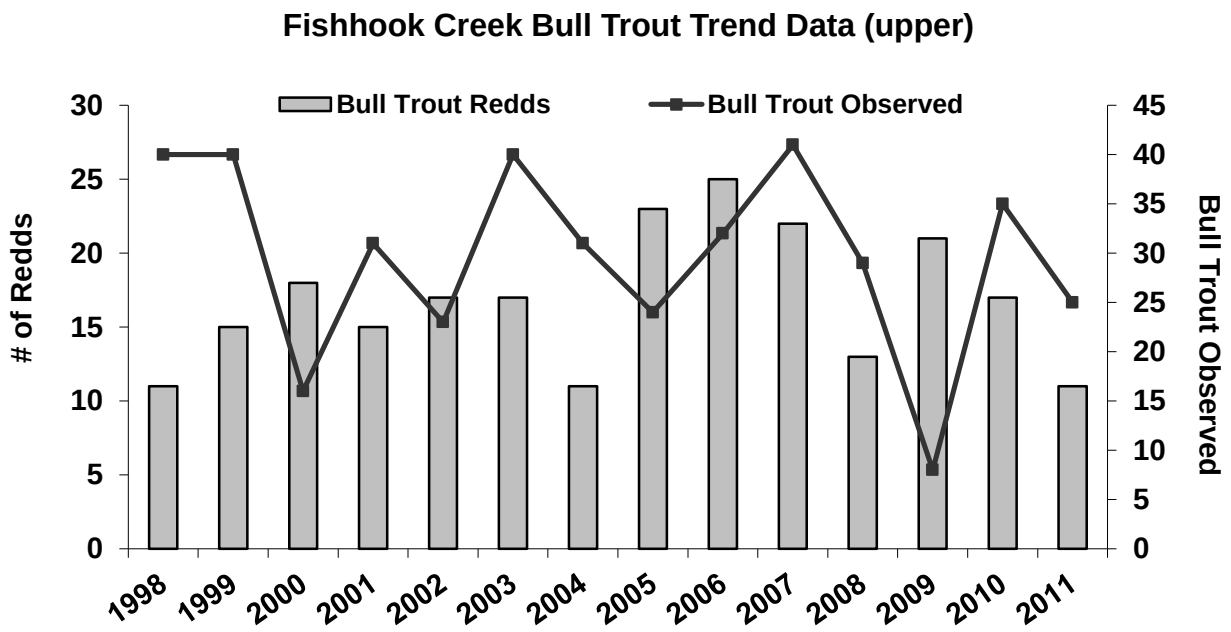

Figure 9. Total estimated bull trout redd counts and peak numbers of bull trout observed from 1998-2011 within Fishhook Creek (upper site).

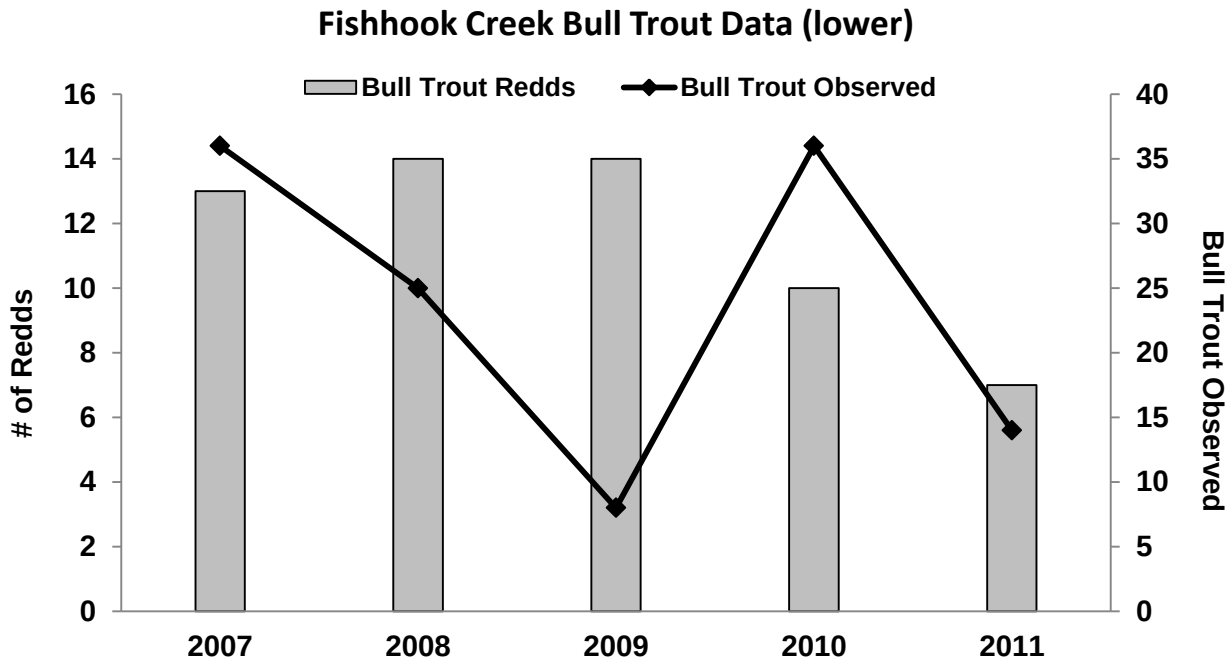

Figure 10. Total estimated bull trout redd counts and peak numbers of bull trout observed from 2007-2011 within Fishhook Creek (lower site).

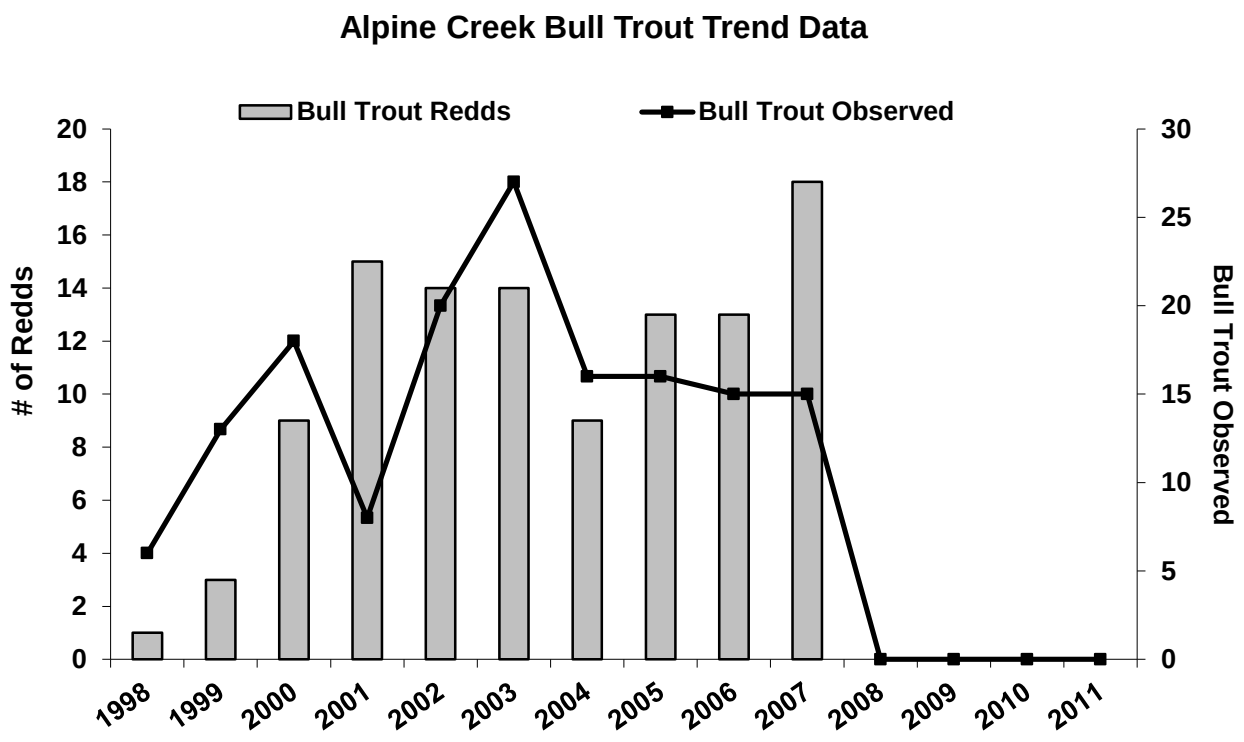

Figure 11. Total estimated bull trout redd counts and peak numbers of bull trout observed from 1998-2011 within Alpine Creek.

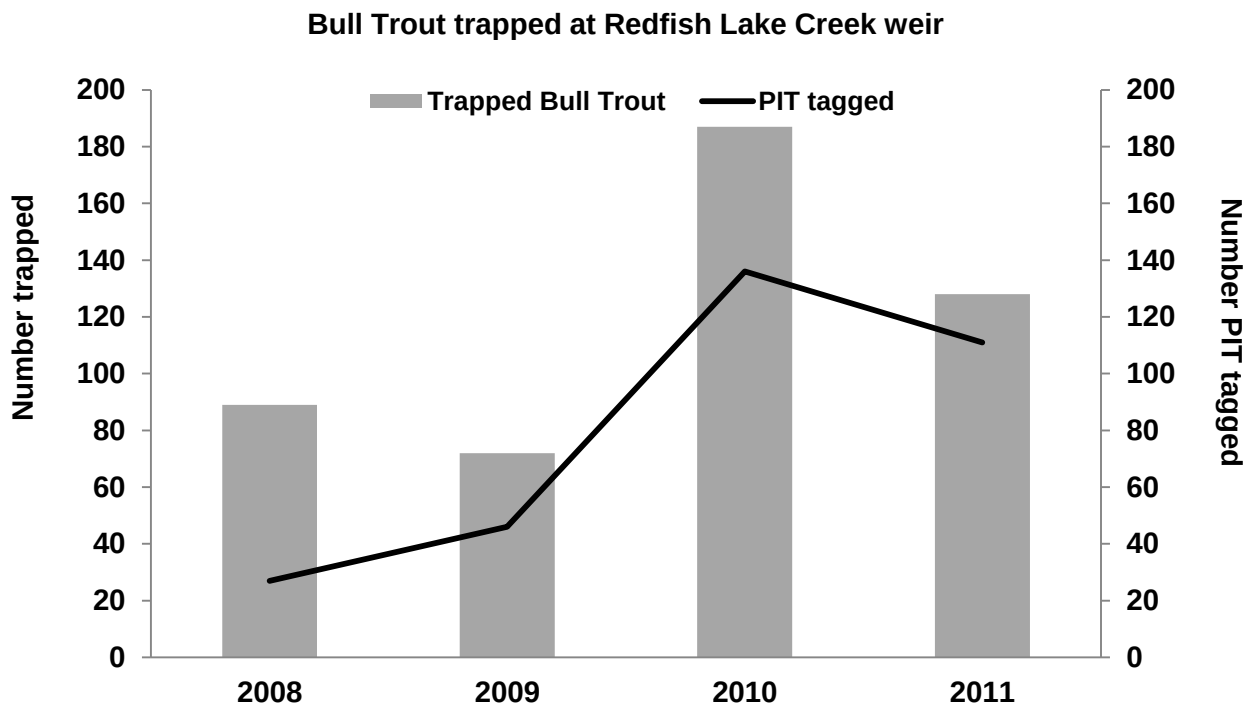

Figure 12. Total bull trout trapped at the adult sockeye weir on Redfish Lake Creek from 2008-2011.

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APPENDICES

Appendix A. Fork length, weight (g), age, and genetic species ID of *O. nerka* captured during midwater trawls conducted during August 2011 on Redfish, Pettit, and Alturas lakes.

Transect	Length (mm)	Weight (g)	Age	Genetic Species ID
Redfish Lake				
1	50	0.9		kokanee
1	53	0.8		unknown *O. nerka*
1	54	1.1		sockeye
1	55	1.3		sockeye
1	57	1.2		kokanee
2	36	0.3	0	sockeye
2	44	0.9	0	sockeye
2	47	1.0	0	kokanee
2	48	1.0	0	kokanee
2	52	1.2		sockeye
2	52	1.0		kokanee
2	53	1.2		kokanee
2	54	1.1		kokanee
2	54	1.2		kokanee
2	57	1.3		kokanee
2	70	2.9		sockeye
3	46	0.6	0	kokanee
3	53	1.1	0	kokanee
3	55	1.2	0	sockeye
3	58	1.5	0	unknown *O. nerka*
3	67	2.3		sockeye
3	69	2.7		kokanee
4	40	0.5	0	kokanee
4	51	1.0		sockeye
4	50	1.0	0	kokanee
4	58	1.7		kokanee
5	45	0.7	0	kokanee
5	51	1.4	0	kokanee
5	54	1.1	0	kokanee
5	58	2.1	0	sockeye
5	63	1.9		sockeye
5	72	2.9	1	sockeye
6	49	1.1	0	kokanee
6	52	1.2	0	kokanee
6	60	1.8	0	sockeye
6	63	2.2	0	sockeye
6	106	10.1		sockeye
Alturas Lake				
1	40	0.4	0	kokanee
1	43	0.5		kokanee
1	45	0.6	0	kokanee
1	55	1.3	0	kokanee
1	53	1.3		kokanee
1	60	2.0	0	kokanee
2	42	0.5		kokanee
2	43	0.5		kokanee
2	50	1.0		kokanee
2	53	1.4	0	kokanee

Appendix A. Continued.

Transect	Length (mm)	Weight (g)	Age	Genetic Species ID
Alturas Lake				
2	53	1.1	0	kokanee
2	70	3.0	1	kokanee
3	35	0.3		kokanee
3	38	0.3		kokanee
3	40	0.5		kokanee
3	40	0.5		kokanee
3	43	0.6		kokanee
3	43	0.5		kokanee
3	45	0.8		unknown *O. nerka*
3	45	0.7		kokanee
3	45	0.8		kokanee
3	45	0.8		kokanee
3	46	0.7		kokanee
3	50	1.0	0	kokanee
3	50	1.1		kokanee
3	50	1.3		kokanee
3	52	1.2		kokanee
3	52	1.2		unknown *O. nerka*
3	53	1.3		kokanee
3	55	1.2	0	kokanee
3	55	1.5		kokanee
3	55	1.4		kokanee
3	56	1.6		kokanee
3	63	2.3	0	kokanee
3	63	2.0	0	kokanee
3	67	2.9		kokanee
3	72	3.5	1	kokanee
3	85	5.6	1	kokanee
3	87	5.9	1	kokanee
4	41	0.4		kokanee
4	42	0.5		kokanee
4	43	0.6		kokanee
4	43	0.6		kokanee
4	45	0.7		kokanee
4	45	0.6	0	kokanee
4	46	0.6		kokanee
4	46	0.7		kokanee
4	48	0.8		kokanee
4	48	0.8		kokanee
4	51	1.0		kokanee
4	52	1.2		kokanee
4	53	1.2	0	kokanee
4	53	1.1		unknown *O. nerka*
4	55	1.3		kokanee
4	55	1.2		kokanee
4	55	1.4		kokanee
4	57	1.4		kokanee
4	58	1.3		kokanee
4	60	1.6	0	kokanee
4	60	1.9	0	kokanee
5	43	0.4		kokanee
5	48	0.9		kokanee

Appendix A. Continued.

Transect	Length (mm)	Weight (g)	Age	Genetic Species ID
Alturas Lake				
5	54	1.1		kokanee
5	55	1.1		kokanee
5	55	1.4		kokanee
5	57	1.4		kokanee
5	65	1.8		kokanee
5	215	94.7	3	kokanee
6	47	0.6		kokanee
6	48	0.8		kokanee
6	50	0.8		kokanee
6	51	0.9		kokanee
6	52	1.1		kokanee
6	52	0.9		kokanee
6	53	1.1		kokanee
6	54	1.1		kokanee
6	57	1.3		kokanee
6	58	1.6		kokanee
6	60	1.8		kokanee
6	87	5.3	1	kokanee
Pettit Lake				
1	43	0.8		unknown *O. nerka*
2	119	16.8	2	unknown *O. nerka*
2	120	19.2	2	kokanee
2	122	21.3	2	unknown *O. nerka*
3	50	1.0		sockeye
5	105	12.3	1	sockeye
6	58	1.8	0	unknown *O. nerka*

Appendix B. Arrival dates at Lower Granite Dam for PIT-tagged sockeye salmon smolts during the 2011 migration year.

	Redfish Lake					Pettit Lake			Alturas Lake		
Date	Natural Origin	Fall Direct	Hatchery Smolts	Oxbow Smolts	Sawtooth Smolts	Natural Origin	Fall Direct	Hatchery Smolts	Natural Origin	Fall Direct	Hatchery Smolts
5/13/2011	1										
5/17/2011					95						
5/18/2011	1			50	259						
5/19/2011	1			307	488					1	
5/20/2011	11			346	653					1	
5/21/2011	6			372	754					3	
5/22/2011	16		2	312	1,494					1	
5/23/2011	7			198	1,344					4	
5/24/2011	9		2	155	1,817					1	
5/25/2011	2		2	75	610						2
5/26/2011	1		1	43	446					1	1
5/27/2011	7		1	27	312					4	2
5/28/2011	2		1	11	142					1	1
5/29/2011	3		4	14	96					1	1
5/30/2011	2		8	13	114					2	1
5/31/2011	3		7	10	126	4					1
6/1/2011	5		52	10	84			1			
6/2/2011	6		33	5	63	1					
6/3/2011	2		21	2	40						2
6/4/2011	7		37	3	54			2			1
6/5/2011	3		19	3	25	5		2			
6/6/2011	3		25	3	38	4		1			
6/7/2011	5		25		53	6		2			
6/8/2011	6		34		61	1		1			
6/9/2011	4		22		30	1					
6/10/2011	2		14	1	14						
6/11/2011	4		7		7						
6/12/2011	1		7		3						
6/13/2011	1		8		2						
6/14/2011			14		1						
6/15/2011	2		5								
6/16/2011	1		8		3						
6/17/2011	2		2								
6/18/2011			5		2						
6/19/2011	1		4		1						
6/20/2011	2		4		1						
6/21/2011	1		4	1							
6/22/2011			1								
6/23/2011	1		3								
6/24/2011			1	1							
6/25/2011											
6/26/2011			2		1						
6/27/2011			1		1						
6/28/2011											
6/29/2011	1										
6/30/2011			1		1						
7/1/2011			1		1						
7/2/2011											
7/3/2011			1		1						
7/4/2011											
7/15/2011			1		1						
Total	**132**		**390**	**1,962**	**9,238**	**22**		**9**		**20**	**12**

Prepared by:

Mike Peterson
Senior Fisheries Research Biologist

Kurtis Plaster
Senior Fisheries Technician

Kip Kruse
Senior Fisheries Technician

Katie McBaine
Fisheries Technician

Christine Kozfkay
Principal Fishery Research Biologist

Approved by:

IDAHO DEPARTMENT OF FISH AND GAME

Daniel J. Schill
Fisheries Research Manager

Edward B. Schriever, Chief
Bureau of Fisheries